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ABSTRACT

This thesis examines what practices schools and school districts need to adopt if they want to apply sustainable design principles to their new schools and the benefits these design practices offer school communities. The paper argues that school districts will benefit from these design principles, and that these benefits will occur because sustainable design and construction decisions lead to the creation of learning environments that are environmentally healthy for occupants, operationally efficient, and site sensitive to the natural and community environment. Also argued is that school districts are best served by being proactive in their embrace of sustainable design principles, and that the adoption of these concepts and processes will be most successful if they involve a collaborative and interdisciplinary project management model that uses project teams and the community throughout the design and construction process. Appendices contain a report on the impact of inadequate school facilities on student learning and the study's interview questions. (Contains 64 references.) (GR)

SCHOOLS OF THE FUTURE AND SUSTAINABLE DESIGN

A Thesis

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In Partial Fulfillment

Of the Requirements

For the Master of Arts Degree

By

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Seattle, Washington
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THESIS ABSTRACT

Schools of the Future and Sustainable Design

Anne Webster Fox

June 2000

This paper is an educational resource that informs the reader about sustainable design and the benefits sustainable design practices offer school communities. Research for this paper was conducted using two key questions as organizational drivers. Those questions are: 1) What practices do schools and school districts need to adopt if they want to apply sustainable design principles to their designs for new school buildings?; and 2) How do school communities benefit from the application of sustainable design principles to new school building design and construction?

In the course of answering those questions, this paper argues that school districts will benefit from the application of sustainable design principles to the design and construction of new schools. The benefits will occur because

sustainable design and construction decisions will lead to creation of learning environments that are environmentally healthy for occupants, operationally efficient and site-sensitive to the natural and community environment into which a project is placed.

This paper also argues that school districts will be best served by being proactive in their embrace of sustainable design principles. School communities will see the greatest gains by taking deliberate action to educate themselves about both the concepts and the processes that are critical to the successful application of sustainable design principles. Finally, adoption of those concepts and processes will be most successful if they are employed using a collaborative and interdisciplinary project management model that involves project teams and the community throughout the design and construction process.

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TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

List of Tables

List of Figures

INTRODUCTION

The poor condition of school buildings nationally has fostered a rallying cry for change. With education issues grabbing headlines and concerns about the state of our education system gaining prominence in government legislative circles there is a growing body of support to fund school building renovation and new design initiatives. The rationale behind this support is twofold. First, the argument is made that students need a healthy and safe environment to support academic goals for learning. Secondly, a case is made to repair and build schools that are cost effective to operate so taxpayer funds are not needlessly wasted and more funds are directly available for student education.

A parallel discussion that is gaining more recognition centers on "green design." Green design refers to design of buildings (such as homes, offices, educational centers) and interior spaces with a commitment to merge environmental and ecological needs with both economic needs and human needs for healthy, and, in the case of workplaces, productive environments. By linking together the two needs – that of green design and the national need for new and updated school buildings – the opportunity exists to apply innovative principles of design and, in particular sustainable design, to plans for new school buildings.

Several components may be considered in looking at sustainable design for schools. They include the built environment (i.e. buildings and facilities), the learning environment and the operations and maintenance environment. The built environment includes the outer shell of the building and the systems and materials that go into making the building a safe and protected shelter for occupants. It also includes the site upon which the building is placed. The learning environment includes the community of people — teachers, administrative and support staff, parents and volunteers – who use curriculum and other teaching materials to work with students to help them reach academic and social goals of learning and achievement. The operations and maintenance environment represents the materials and systems that are required to keep the school building and grounds operating safely and cost effectively.

The components, the built, learning and operations and maintenance environments, are interdependent but, for the purposes of this paper, the discussion will focus on the built environment. To begin the discussion, this paper analyzes and discusses both the history of school building design and the current condition of school buildings. Those issues are analyzed in light of the impact that both antiquated design and decayed building structures have on student learning. In Chapter II, concepts of sustainable design are introduced and discussed. Chapter III is a discussion of applications to school design of specific sustainable design principles. Chapter IV links the use of particular sustainable design features to impacts on student performance. The last chapter describes the experience of three school districts that have incorporated sustainable design principles into their new school buildings.

CHAPTER I

ARGUMENTS FOR CHANGE: THE CONDITION OF SCHOOLS TODAY

We have moved through significant change in our attitudes toward the schoolhouse over the course of our history. Our attitudes towards education and our beliefs in how children should be taught are often reflected by the style and condition of our school buildings. Those attitudes and beliefs may be communicated through particular designs of school environments and in the ways we maintain and care for, or neglect, those environments. In considering a school's place within a community, it is instructive to analyze a community's actions towards its children by looking at the various approaches to school design, building and maintenance that were taken during different periods of history.

In our early history, the schoolhouse was introduced as a need by educators who argued for the importance of an educational site unto its own to insure the proper education of children. Once the idea of a building to house students gained acceptance, the size and style of the buildings themselves went through various transformations that were influenced both by the politics and social perceptions of the times as well as the knowledge of building techniques and materials. Regardless of the times, however, economy and efficiency were consistent drivers in the definition of design parameters. In many schools, those parameters took precedence over other specifications that may have resulted in designs that worked more effectively as learning environments.

Where has our history led us? The remainder of this chapter addresses that question. The chapter includes a brief discussion of the history of schoolhouse design, a description of the state of our schools today and the consequences we face as a result of our approach not only to schoolhouse design, but also to operations and maintenance of schools. The argument is made that decisions of the past have led to today's reality where, in many districts across the county, schoolhouse conditions negatively impact our children's ability to learn.

The Evolving Schoolhouse

The first American schools were in homes or churches where, for those of wealth, children were taught by tutors. Families with fewer financial resources had their children schooled in the homes of older women who were most likely widowed (Graves, 1993). In the early nineteenth century, as populations began to increase and America grew as a country, the idea of a separate site for schooling children began to evolve. Cutler (1989) comments that early educators such as Horace Mann, a champion of free, universal and nonsectarian education, believed children "could not learn to meet their moral obligations or reach their cognitive potential outside a special environment" (p. 2). Schooling became a matter of teaching children to become responsible citizens in a democratic society by their exposure not only to particular curriculum, but also to learning that curriculum in a distinct setting – the schoolhouse. The schoolhouse became the means, by the nature of its physical environment, for providing children a directed, learning experience.

Education, in the first half of the nineteenth century, evolved into a formal, organized enterprise which was separated from work and family. In its new form, it required a building to house the students. Horace Mann related schools to architecture in comments he made in his first annual report as secretary of the Massachusetts Board of Education. He stated that schoolhouse design is closely connected to "the love of study...proficiency, health, anatomical formation, and length of life. These are great interests and therefore great duties" (Cutler, 1989). Educators then, as now, worked to promote learning by arguing for the importance of school settings and for the funds required to create those settings.

The earliest schoolhouses were one room designs. Although we may idealize them as "little red schoolhouses" they were more often dirty and noisy and a difficult setting in which to learn (Graves, 1993). Cutler (1989) remarks that "support for better schoolhouses rose in part from the depressing, even unhealthful, condition of many public schools. It was unpleasant to work in buildings without adequate light, heat, air space or sanitation" (p. 6).

Although one-room schoolhouses exist to this day, the growing population in cities as well as evolving education theory led, in the mid-1800s, to changes in the size and design of schools. In 1848, Boston's Quincy Grammar School was built as the first fully graded public school. The interior layout included classrooms that allowed for greater supervision of students and specialization of instruction. Interestingly, the classrooms were about 800 square feet, the size of many classrooms in today's schools (Graves, 1993).

Over time, educators took control of school planning and construction. After 1900, a "corps of specialists" in school architecture began to emerge. Large urban districts formed architectural departments. By 1931, a Bureau of School Buildings and Grounds was founded in 19 states. Those Bureaus became a force for standardization of school design. Professional architects were involved primarily as structural engineers or as "decorative facadists." The layout and design ideas came from educators who were interested in shaping the form of education and instructional delivery (Bradley, 1997). Many in the field of school architecture spoke out against the uniformity of design, but districts looked at the savings realized in standardization. Those who spoke out against standardization argued that a "rubber stamp" approach to building design resulted in schoolhouses being treated as factories not places of learning. To follow through on the argument critics stated that it was the same as trying to standardize education (Cutler, 1989).

Even as the interior conditions of schools improved dramatically across the country during the first half of the twentieth century, the architectural design "stood still" with a few notable exceptions. As Graves (1993) comments, whether the school faces were

> Gothic, Spanish, Colonial, Greek Revival or Victorian, (the school buildings themselves) were essentially clusters of one-room schools,

> stacked up for two or three stories, to which a cavernous gymnasium and auditorium were often added along with a few other specialized spaces such as a library, office and cafeteria. Despite local autonomy in school matters these buildings are startling in their national similarity" (p. 25).

Despite the similarities in the outer shell construction of schools, the addition of classrooms and specialized spaces indicated that thought was going into recognizing the connection between curriculum and the building that housed the educational program (Bradley, 1997). Recognition came in reaction to the typical, regimented educational program of the early twentieth century.

Educator and philosopher, John Dewey, believed children learned best by participating in an activity. The impact of those beliefs led, in the first quarter of the 1900s, to broader curriculum offerings and, therefore, a need for spaces to accommodate new or expanded subjects. Spaces were designed for subjects such as science, art and vocational training and, recognizing the importance of play in a child's educational experience, for playgrounds.

In 1940, planning for a new progressive school began. Crow Elementary School is a first example of a collaborative effort between architects and educators to design a school where a conscious choice was made to enhance the learning and teaching experience through effective design of the building. The idea for collaboration originated with a Winnetka, Illinois superintendent, Carleton W. Washburne. Graves (1993) comments that, upon completion, the Crow Elementary School represented a complete rejection of the Victorian schoolhouse design of imposing scale, formality and fixed organization of classrooms set within a two- to three-story box like structure. In contrast to those designs, the Crow School represented a successful creation of a design built "to the scale of children and an environment that promoted a sense of belonging" (Meek, 1995, p. 57).

As hopeful as some may have viewed the outcome of the Crow Island design, the philosophy used to define that built environment was not to continue to grow into a significant force for change in school design. The onslaught of World War II changed priorities. Post-war, the growing population of "baby-boomers" put intense stress on school districts to build quickly and efficiently to meet the demand. Between 1950 and 1960 approximately 60,000 new classrooms were built *each year*. The age of mobility began with corporations moving employees as often as every year and families moving from urban centers out to the suburbs. About 20 percent of the U.S. population moved every year (Committee on Architecture for Education (CAE): Renovating early and middle 20th century schools, 1999).

Responding to this new, evolving growth of mobility and instantly built suburban communities, school districts built "ubiquitous single-story, metal-framed, glass-walled K-12 school buildings..." (CAE: Renovating early and middle 20th century schools, 1999, p. 2). The Committee on Architecture for Education (CAE) article points to several factors that contributed to this design: a 50 percent higher school enrollment; mass movement to the suburbs; low tax bases in suburbs for development of infrastructure or schools; a need for fast-tracked, simple schools; low energy costs; and an emphasis on cheap construction with quantity more important than quality. Anne Taylor comments that forty-three percent of U.S. School buildings were built "cheaply and rapidly" in the 1950s and 1960s (Meek, 1995, p.68).

The pattern in the five decades after World War II has seen alternating periods of a rise and then a fall in school enrollment (Brubaker, 1998). Building and renovation of schools has reflected that rise and fall with school districts often poorly equipped to effectively deal with the fluctuations and, as a result, missing opportunities to speak to quality and innovative design for schools. In a paper presented at a CAE conference, Sarah Woodhead compared schools during three different periods in history. She noted that educators and designers were more responsive to human health concerns prior to WWII than since (CAE: Renovating early and middle 20th century schools, 1999). Brubaker makes the same point by describing early century designs in California, Texas and Florida where "finger plan" campuses were intentionally designed to capture the advantages offered by natural light patterns and ventilation flows (Graves, 1993).

Designs by William B. Ittner, an influential St. Louis architect, offer additional examples of the care taken to design schools in the beginning of the twentieth century. He employed open "H" and "E" design plans to orient schools, similar to the "finger plan," to take advantage of natural light and ventilation benefits. He used light wells to bring in natural light and architectural detailing in brick, tile, stained glass and other materials to enhance the beauty of the school. His kindergarten rooms were twice the usual size of other rooms and had bay windows and fireplaces. He used landscaping to mask the starkness of the building and merge the sense of an interior and exterior space (CAE: Renovating early and middle 20th century schools, 1999).

The Current State of School Buildings

Schools are the most numerous and identifiable public buildings in the United States. (Cutler, 1989) Over time, communities have spent enormous sums of money to invest in schools. Despite the expenditures, the current state of school buildings is, for the greater part of the country, dismal. The following description from a by the U.S. Department of Education (1999) describes the problem:

> Communities across the country are struggling to address critical needs to renovate existing schools and build new ones. School construction and modernization are necessary to address urgent safety and facility needs, to accommodate rising student enrollments, to help reduce class sizes, to make sure schools are accessible to all students, and to modernize buildings so they are well-equipped for the 21st century (p. 1).

Reflecting pressure from tight budgets and difficulty in getting approval for new building, school districts have deferred both maintenance and modernization for their schools. Maintenance allocations dropped significantly to 9.4 percent of net current expenditure in 1997 from 12.75 percent allocation in 1988 (Lyons, 1999). School buildings across the country are dated and, in many cases, beyond their useful life. In his report on K-12 School Construction Facts and an Overview of Elementary and Secondary Educational Facilities, Lyons articulates the challenges we face today. He notes that a National Governors' 1989 survey of public elementary and secondary school buildings documented 103,000 school buildings in use. That number represents approximately sixty-six percent of all educational complexes in the United States. The school districts housing those buildings educate 96.9 percent of all students, or 47,200,000 students as of 1999. Of those school buildings, as noted earlier, 43 percent were built in the 1950s and 1960s. Of the remaining schools, 31 percent are more than 50 years old and roughly one quarter were built within the last 25 years (as of 1997) (Probe, 1997). The scale of the challenge ahead of us looms large after looking at these figures. Added to those numbers are the realities districts face with tight budgets, tax revolts by voters, increasing school-age populations and immense costs caused by the consequences of years of deferred maintenance.

Since today's schools were built, major changes in instructional programs, technology and environmental health awareness have emerged. The schools are poorly equipped to deal with the demands for learning in the Twenty-first century. Severely deficient environmental conditions highlight the problem even more vividly. Lighting, heating, ventilation and energy efficiency are substandard in regions across the country. Although communities of all types (urban, suburban, and rural) are affected by the poor conditions, schools in urban centers have the highest percentage of schools with "unsatisfactory environmental conditions" (Lyons, 1999). Communities are facing the challenge of major building and renovation initiatives in response to these conditions and to the projected and current rapid rise in school-age populations.

In March of 1998, the Secretary of the U.S. Department of Education, Richard W. Riley, spoke about the current state of schools in America to a construction forum in Phoenix, Arizona. Participants included educators, parents and elected officials. He commented:

> Research shows that a safe, welcoming, and up-to-date learning environment is the building block for student academic success. This is why I am joining parents, teachers, and community and business leaders who are working hard to get broad public engagement to rebuild and modernize our nation's schools (p. 1).

In his introductory statement at the Phoenix Construction Forum Conference, Riley refers to a report by the American Society of Civil Engineers that describes schools as being in the "worst shape (of) any other infrastructure in America." There are major problems with maintenance and repair, obsolescent spaces and mechanical systems, environmental hazards, overcrowding and unsound structures. One third of schools, housing 14 million students, need extensive repair or replacement. The GAO reports that 28,100 schools serving 15 million students have less-than-adequate heating, ventilation, and air-conditioning systems; 23,100 schools serving 12 million students have less-than-adequate plumbing; and 21,100 schools serving 12 million students have less-than-adequate roofs. (Council of Educational Facility Planners, International, 1998). Forty-six percent of schools have inadequate wiring for computers, communications and technology (Lyons, 1999).

Schools today are in urgent need of repair and modernization, and school districts experiencing overcrowding need new construction to accommodate swelling populations of school-age children. A 1995 General Accounting Office report states that $112 billion is needed to modernize and build schools to bring our school infrastructure up to acceptable standards. That number does not include an estimated $20 billion in new K-12 school facilities that is projected as needed to meet growing school populations. The U.S. Department of Education estimates that by 2002 enrollments at public elementary and secondary schools will grow by 1.3 million students.

It is difficult to question negative impacts of school conditions and design on students' abilities to learn when we hear about the experience of the East St. Louis School District 189. In 1997, Richard B. Wells assumed responsibility for the position of Director of Business and Operations for SD 189. He faced immense challenges. The 26 schools in the district were severely neglected after a 20-year history of emergency-only maintenance. One building was condemned; a merger was expected to add 1,700 students to the district; the District was under state control because of the extreme nature of administrative and financial problems. Wells described the conditions under which students were expected to learn: "classrooms with no electrical outlets, constant ceiling leaks, teachers continuously holding the fire alarm button to prevent the alarm from sounding, and rats in the student restrooms" (CAE: Renovating early and middle 20th century schools, 1999, p. Topic 1-4). While Wells was, impressively, able to turn around the conditions in SD 189, the fact that he was faced with such appalling conditions at all is disheartening.

The fact that SD 189 existed and that it is not an isolated case is a clear statement of our neglect to uphold even minimal maintenance standards in school buildings across our country. It also communicates the values we hold about education and about our children. Anne Taylor comments:

> Because architecture can facilitate the transmission of cultural values, we need to look at what our present school buildings are saying to our children. We expect schools to prepare children for living in a democratic society, yet we provide a learning environment that resembles a police state – hard, overly durable architecture, giant chain-link fences, locked gates, guards, and even guard dogs (Meek, 1995, p. 69).

Similarly, by expecting students to attend school in buildings that are in such disrepair as to be almost uninhabitable, we are effectively telling our children that we do not value them enough to provide environments that enhance, rather than detract from, their learning experience.

Observations about how the poor physical and environmental conditions of schools negatively impact students' abilities and willingness to learn is not, however, enough to convince funding sources to support change. Specific measures are required to show evidence of the need for change. Fortunately, there are numerous studies that document the negative effects that poor school building conditions have on student achievement. Appendix A contains a U.S. Department of Education summary of a number of studies documenting the impact of inadequate school facilities on student learning. At the end of that summary is a comprehensive listing of references. The references are intended to be a useful resource for the reader. Note, however, that other than noted in the following paragraph, this author did not read each of the studies listed in Appendix A to analyze them for validity of results.

The U.S. Department of Education report summary documents six different studies of impacts on student achievement and three studies of impacts on teachers' abilities to do their job effectively. Several of the studies, after controlling for socioeconomic and other variables, found that student performance results were lower in schools with poor building conditions as compared to schools in fair or excellent condition. (See Appendix A: Edwards, 1991; Cash, 1993; Hines, 1996.) A 1995 study by Earthman refers to the Edwards and Cash studies, and observes that results of those studies, along with results from his study, support the positive correlation "between the condition of a school building and the performance of students on achievement tests" (1995, p. 13).

Given the documented need for major repair, renovation and construction of our nation's schools, the opportunity exists for innovators to point school design efforts in a new direction. A discussion of those efforts follow first in Chapter II, where concepts of sustainable design are discussed and, second, in Chapter III where concepts of sustainable design are linked to a discussion about the design for schools.

CHAPTER II

SCHOOLS OF YESTERDAY AND TOMORROW: INTRODUCING CONCEPTS OF SUSTAINABLE DESIGN

Over the last decade, in the 1990s, the terms "sustainability and "sustainable development" have received more and more attention. Increased use of the terms have caused some to comment that they are becoming commonplace enough to assume people understand the concepts behind the terms. Others would dispute that assumption simply by answering a question about sustainability with a blank stare. When understanding is acknowledged it is often in situations where the concept of sustainable practices is applied in a very limited and linear way rather than as a concept that crosses disciplines.

It is no surprise that there is a discrepancy in the levels of understanding about issues of sustainability and sustainable practices. As applied, "sustainability" is a new term in our vocabulary. Of greater significance, however, is the fact that it is not a term with a simple one-line definition. It represents, rather, a process that incorporates the systems of numerous other disciplines. The key to understanding the definition is to realize that sustainability does not happen in a vacuum. Sustainable practices must be, by definition, considered as an integral element in all systems that impact our environmental, social and economic health.

Reflecting the newness of the term, it is instructive to note that, between the publication in 1988 of Webster's Third Edition Collegiate Dictionary and Webster's Tenth Edition in 1999, the definition of the word "sustainable" was expanded to include specific reference to resource use. The definition in the 1999 edition states: "Of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged." This definition offers a foundation from which to move into a broader definition that is appropriate for the purposes of this paper. A broader definition is explored in the following discussion by reviewing the philosophies and thoughts of some important innovators in the discipline of design.

Robert Berkebile is the founding chairperson of the American Institute of Architects' Committee on the Environment. Through a working partnership with the Environmental Protection Agency, manufacturers and environmental groups, he has helped to create the American Institute of Architects Resource Guide. The Guide is a comprehensive and continually updated publication on the ecological impact of architectural decisions. Berkebile believes that labeling ecologically conscious design "green" or "sustainable" is limiting because the terms imply survival rather than thriving. His point is that architectural design must be guided by the "needs of a rapidly expanding population with shrinking resources" and by the knowledge that buildings will, just by scale alone, modify the complex natural systems upon which we, the users of buildings, are dependent (Zeiher, 1996).

Berkebile, instead, is a proponent of making design decisions that lead to renewal and restoration by contributing to the social, economic and environmental well-being of individuals and communities. He comments: "It has become clear that if we care about our children's future, we can no longer be satisfied (only) with reducing the environmental impact of our designs" (Zeiher, 1996, p. 31). He recognizes the complexity of the design process and its impact on natural and human systems while at the same time speaking optimistically about the opportunities a holistic approach to design promises. In concluding remarks about Berkebile, author Laura C. Zeiher (1996) offers a summary of his belief in the potential for positive design outcomes.

> If we embrace rather than shirk the diversity and interdependence of all life with our designs, we find the outcome can move far beyond efficiency and performance. The result can touch the heart, elevate the spirit, and inform us of the potential for celebration and community building at every scale (p. 31).

Within the world of design and industrial design, William McDonough, an architect, designer, and a Dean and Professor of Architecture at the University of Virginia, has transformed assumptions and techniques by embracing and articulating a philosophy of sustainable design. His early model of sustainable design is reflected in the Hannover Principles. McDonough's office was commissioned by the German government in 1992 to develop design principles for the EXPO 2000 World's Fair. The Fair, to be hosted in Hannover, Germany, was being promoted under the theme "Humanity, Nature and Technology."

McDonough wrote the Principles for the international design competitions to inform all competitors of the guidelines that must be considered in order to qualify for consideration as a participant in creating the built environment for the Fair.

The Principles speak directly to concepts of inter- and co-dependency between human and natural systems and to the need to eliminate waste in design and construction, to use natural energy flows to power buildings and to communicate across disciplines to enhance sustainable practices in design. The Principles are based on the premise that we should design for future generations by making conscious and deliberate design decisions that are "an environmentally sensitive and responsible expression as part of the evolving matrix of nature" (Zeiher, 1996, p. 48).

Since developing the Hannover Principles, McDonough has continued to examine and redefine aspects of sustainable design. In a presentation in which he referred to Thomas Jefferson's view of natural resources he commented:

> Sustainable design simply means to me that no one can desecrate the land they own or occupy to debts greater than those that can be paid during their own lifetime, because if they could, then the world would belong to the dead, and not the living. So the question is, how does the world belong to the living? And it's not just the "natural rights " of human beings that must concern us; it's also the rights of nature itself (Zeiher, p. 48).

How does the world belong to the living? His words are reminiscent of Berkebile's thoughts that we should focus with the intent to thrive, not merely to survive.

Sim Van Der Ryn and Stuart Cowan, in *Ecological Design*, discuss concepts about sustainable design similar to those of McDonough. The authors argue that sustainability needs to be "firmly grounded in the nitty-gritty details of design" (p. ix). Their argument arises from the same foundation as the argument made by McDonough. We must base design on integration with living systems and processes in order to minimize or avoid environmentally destructive impacts. To achieve that goal, just as natural processes are linked and interdependent, we must also link and make interdependent our communications between disciplines throughout the design process.

Van Der Ryn and Cowan use of the word "ecological" is indicative of the premise upon which they base their argument. Ecology, a branch of the biological sciences, deals with the relations of organisms to one another and to their physical surroundings. It is concerned with how individual organisms and populations of organisms live together and with their environmental surroundings. Ecology precepts assume that no living organism exists entirely by itself. An organism is rather, part of a community of organisms that interacts and has an effect on other communities and on its environment. Van Der Ryn and Cowan define ecological design as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes." They go on to comment that:

> By placing ecology in the foreground of design, it provides specific ways of minimizing energy and materials use, reducing pollution, preserving habitat, and fostering community, health, and beauty. It provides a new way of *thinking about* design" (p. x).

Clearly the message is that, in order to preserve the natural systems upon which we depend, we must create design parameters that compliment and enhance those systems; that work within and as a part of them, rather than separate and apart.

In talking further about the concepts and basis of ecological design, Van Der Ryn and Cowan are careful to define and analyze the meaning of the word "design." Through design, we shape the physical details of our everyday experiences. By the "intentional shaping of matter, energy, and process to meet a perceived need or desire," design reflects what we value within our culture (p.8). In yesterday's and today's world our design reflects our approach to living separate and apart from our natural world. In terms of survival, it is logical that we would build shelters and design processes to protect ourselves from the vagaries of the elements and from threats to our safety. And yet, we have taken that design to levels where we make design decisions in isolation from considerations of their ecological consequences.

The goal of sustainable design is to recognize our connection with the living world. Using that belief as a premise, we may begin to work with natural processes in complimentary ways to protect the environment upon which we depend. Although Van Der Ryn and Cowan use the term "ecological design," it may be considered complimentary to the term used in this paper, "sustainable design." To quote their definition and explanation:

> We define *ecological design* as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes." This integration implies that the design respects species diversity, minimizes resource depletion, preserves nutrient and water cycles, maintains habitat quality, and attends to all the other preconditions of human and ecosystem health....It is not a style. It is a form of engagement and partnership with nature that is not bound to a particular design profession.....Ecological design is simply the effective *adaptation*

> *to* and *integration with* nature's processes. It proceeds from considerations of health and wholeness, and tests its solutions with a careful accounting of their *full* environmental impacts. It compels us to ask new questions of each design: Does it enhance and heal the living world, or does it diminish it? Does it preserve relevant ecological structure and process, or does it degrade it?" (p. 18).

Other views, perhaps more grounded in common language, are offered by Tom Paladino and David Early. Paladino, a Seattle-based consultant in sustainable design, describes sustainable building design as a means of seeking to maximize the human quality of life while minimizing environmental impacts. In a 1993 article in *The Urban Ecologist*, David Early states that:

> Sustainable design includes specific attitudes towards land use, transportation, natural systems, technology and community, as well as an underlying philosophy that emphasizes the continuity of the uniqueness of certain places (Stover, p. 43).

Sustainable design is site sensitive where, for example, drainage plans work with natural systems, not against them and habitat protection is valued. It employs resource conservation practices such as energy conservation and/or use of natural energy systems (such as solar or wind power), avoidance of toxic materials, and water conservation. Another element is the critical importance of connecting design to place. What is the history of the site and its locale that brings a unique quality to the design concept (Stover, 1997, p. 43)?

Sustainable design, as this discussion shows, may be described using a variety of concepts and terms. The common theme throughout, however, is the interdisciplinary nature of design that is grounded in a respect for the natural systems and communities that will be impacted by that design. Sustainable design, then, uses a deliberate, interdisciplinary approach to design and planning. It assumes, by definition, that a balanced consideration of environmental, social and economic health is applied to design and planning processes. Borrowing from the concept of sustainability as introduced in *Our Common Future*, applications of sustainability may be viewed as requisite practices to assure the health and well-being of present and future generations and of the natural systems that are essential for their continued existence.

As noted earlier, discussions of sustainability frequently include references to holistic analysis and thinking. It is important to recognize a link between the concepts because sustainability is based on the premise that, between the three systems of environmental health, social health and economic health, one system overpowering another creates inequitable balances that threaten the health of all

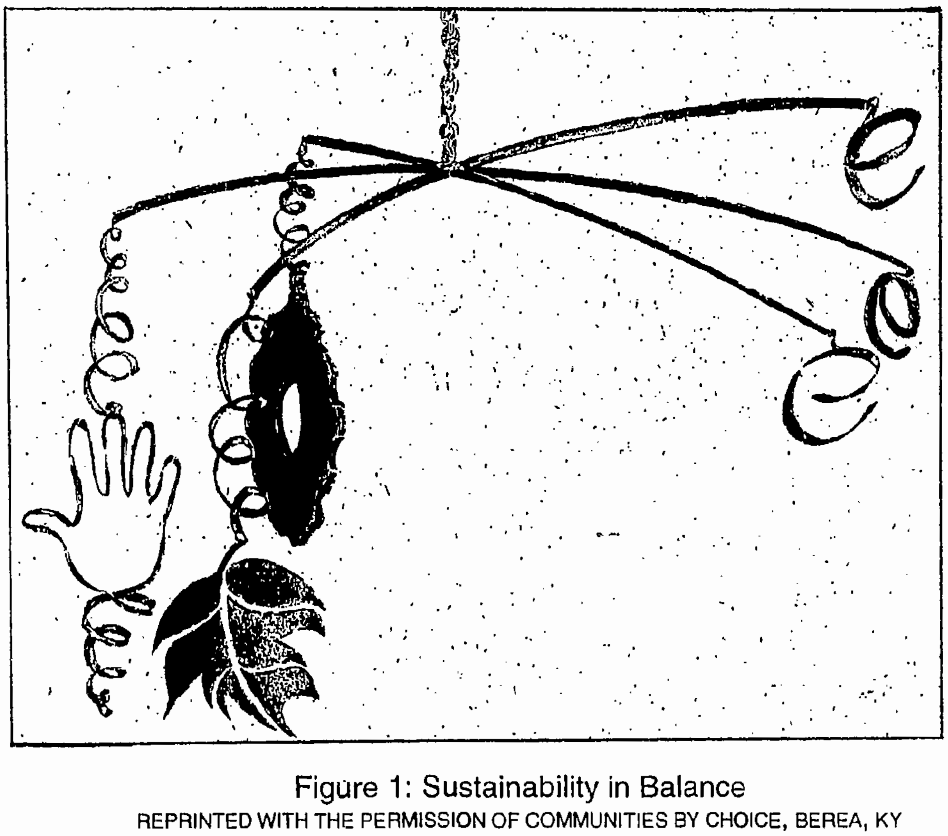

Figure 1: Sustainability in Balance

three. A brochure by the organization Communities by Choice, in Berea, Kentucky, includes a wonderful depiction of this concept on its cover (Figure 1). The cover itself is a soft, warm cream color made of 100 percent post-consumer recycled paper that is flecked with specs of darker fiber. The drawing on the cover is loosely outlined in black pen with the color applied as a wash of earth toned watercolors. The picture itself is of a mobile.

As with any mobile, should one piece be lost or chipped or should the piece securing the three blades be shifted in one direction or the other, the balance is lost. It is an appropriate symbol of sustainability, not only because it depicts the precious nature of the complex systems upon which we depend but also because it is a gracious drawing. It speaks holistically to our intellectual sense through an artistic rendering.

CHAPTER III

PRACTICAL APPLICATIONS: SUSTAINABLE DESIGN AND SCHOOLS

For centuries buildings have been viewed as a way to live apart from and protected from the natural environment. We have grown used to modifying nature and the environment to suit our needs. We have become particularly skilled at this as scientific and technological knowledge has grown in depth and complexity over the last two hundred years. Increasingly isolating ourselves from natural processes, we have placed additional stresses on our environment through continued worldwide population growth and, particularly in western countries (most notably the United States), increased levels of consumption. We have cut trees, drained wetlands and exterminated species both intentionally and unintentionally. Through development and urbanization we have created living centers of impervious surfaces and watched as those centers have sprawled into rural and farmland areas. Our attitude has been one of "the environment versus us" (Kibert, 1999).

The architects and designers whose works were discussed in the preceding chapter have demonstrated how the built environment may be designed to counter this traditional view. It may, instead, be designed to mimic and complement natural systems where the outcomes lead to design that is restorative to natural systems and, at the human level, to a sense of well-being. In a book titled *A Green Vitruvius* the authors, members of the Energy Group for the European Commission, explain the reason for their choice of title:

> 2000 years ago the Roman architect Marcus Vitruvius Pollio wrote the ten books on architecture still referred to in every European architect's education. ....The concept of the architectural pattern book offering design principles as well as solutions is universally familiar. This book is intended as a green pattern book for today.....To the Vitruvian triad of commodity, firmness and delight we postulate the addition of a fourth ideal: restitutias or restitution, restoration, reinstatement: where the act of building enhances its immediate and the global environment in an ecological as well as visual sense" (Foreword).

Adding the "fourth ideal," restoration, links sustainable design to place. It becomes place-sensitive by respecting the landscape, the natural systems that support the landscape, and the cultural heritage that is linked to the landscape.

Transferring these ideas to the built environment for schools is the subject of this chapter. The field of education is under intense scrutiny to adopt methods of instruction to meet the needs of Twenty-first Century learners. Educators are being challenged to move away from the "factory model" where authority is centralized and flows from the top down. There is a push for national standards and for new roles for teachers and students where facilitation and collaboration are emphasized (Meek, 1995).

Given the pressures for change and the nature of change educators and others are seeking, it becomes imperative to include thinking about the places for learning – schoolhouses – as part of the formula for change. Anne Taylor notes that, typically, talks of school reform and restructuring have not addressed the physical learning environment as a support system for education. Using architectural elements as tools to enhance children's learning is a relatively new education reform idea. If we intend to decentralize schools and transform education delivery practices and processes to enhance the learning environment, then we must put thought into the physical context in which these activities take place (Meek, 1996, p. 68).

The dramatic needs for school renovation and new construction, as documented in Chapter One, provide a unique opportunity not only to use design to support the needs of educational reform, but also to simultaneously integrate principles of sustainable design to enhance those goals. Seizing upon the opportunities at hand is particularly relevant for three reasons.

One, given the scale across the nation of the problem of decaying buildings there is the opportunity to make real impacts on design, the environment and the communities affected by a project. A second reason to integrate principles of sustainable design is the potential benefits students are likely to realize through improved performance and achievement by attending school in learning environments tailored to support and enhance educational goals. Lastly, use of sustainable design practices in buildings can result in substantial savings in operations and maintenance over the life of a building. The remainder of this chapter discusses different elements of sustainable design that benefit both the operating performance of schools and the natural environments in which they are built. The following chapter, Chapter IV, complements and enhances this discussion by describing the positive impacts certain sustainable design features may have on student performance.

Schools and the Design Challenge

Daniel L. Duke, as a professor and director of the Thomas Jefferson Center for Educational Design at the University of Virginia, is intimately involved with research and design for centers of education. He acknowledges that we have entered into an "era of major school construction and renovation" caused by the combination of growing, shifting populations and aging, deteriorating educational infrastructures. Concurrently, communities across the nation, as well as governmental bodies, are questioning the structures for learning that are in place inside schools. By linking these two observations, Duke makes an important point:

> To build or rebuild our schools without rethinking the experiences that take place within them seems as unwise as revamping teaching and learning without considering new designs for learning environments. Together, these trends create an opportunity to redesign both schools *and* schooling (1998, p. 688).

In considering the built environment, a sustainable design approach offers many advantages to traditional design of schools. Those advantages include cost savings through design of integrated systems and plans for multi- and flexible-use facilities. Cost savings may also be realized through use of specific design features such as daylighting, acoustical sensitivity, and use of non-toxic materials that promote learning by creating healthier interior environments. Sustainable design incorporates collaborative and integrative planning processes from the start of a design plan. The benefits gained by communications within a school community are immense.

> It is not our goal to be a green building. It is not our goal to be an energy efficient building. Our goal is to be an educational facility and be the best educational facility we can be. Green buildings, energy-efficient buildings are strategies to reach that goal (Ohrenshall, 1999, p. 1)

These words, spoken by Bill Dierdorff of the North Clackamas School District in Oregon, are important guides to focusing on the reasons for considering sustainable design for new school buildings. Sustainable design is not an end in itself. It is, rather, a way to create a model learning facility through architectural means. This goal is achieved by including specific design features that promote learning, and that create a welcoming, healthy, cost effective and environmentally responsible building. A learning facility is obviously more than just a complex of buildings on a site. It requires a program to support learning, the skills and experience of staff to teach students, and an administrative and operational team that works to provide the resources to keep the school building and programs effectively operating. Although those features are not part of the discussion of this paper, it is important to keep in mind that they are critical to the success of any school community.

Just as sustainable design is a collaborative process, so too is the planning for a successful school community. The design of the school, together with the planning for programs, faculty and staff development and financial and operational management are all essential elements that work together to determine the success of an educational facility in meeting its primary goal of becoming a learning community.

In his thesis entitled "Perceptions About the Role of Architecture in Education," William Scott Bradley lays a foundation for his discussion by offering a definition of architecture and by articulating the role of architecture in education. Architecture itself includes the school building, the learning environments within it, the landscaped site that includes the building, the infrastructure that supports mechanical systems, aesthetic details, instructional equipment, and anything that is created by users to adapt the environment to their needs. He describes five elements that are critical to architectural design if it is to meet the key goal of enhancing education. Those elements are architecture as facility, as place, as signpost, as textbook and as agent.

As a facility, architecture makes learning possible. It is sized, for example to meet enrollment projections and is designed to meet the requirements of and support curriculum. As a place, a high value is assigned to the everyday lives of people. The school becomes a place that students and staff relate to in positive ways. It is inviting, aesthetically pleasing, and contains features that promote learning and that help to create an exciting educational environment. By being a signpost a school facility includes features that clearly define important spaces such as entryways, circulation patterns or high activity spaces. A school building is also a textbook by its use of design to support curriculum goals and to help make the learning environment more meaningful. Finally, architecture may be used as a beacon to signify an agent of change. "Applied to education it encourages and provides opportunities for changes in the method of instruction chosen by teachers or approaches to learning taken by students" (Bradley, 1996, p. 105).

Using Bradley's definition of architecture's role in education as a base, it is possible to expand upon his ideas by incorporating concepts of sustainable design into his definition. Sustainable design may be used as a tool for learning the importance of respecting the dependency of human systems on natural systems and how we should, therefore, design our communities to respect that relationship. It also may be used to show students and the adults that teach and work with those students how collaborative work leads to positive outcomes through innovative approaches to problem-solving. Through sustainable design, a school building may become more than just a "facility." It may become a place that represents a community of learning in more than one sense - a meaningful symbol of respect for the environmental, physical and economic health of a community.

In June 1998 a group of architects, planners, school board members, teachers and representatives from federal agencies met to discuss and consider best practices in designing environments for learning. The practices were presented in draft form at a national symposium held in Washington D.C. later that year. The results presented included a set of three conditions and six principles. The conditions were: 1) learning is a lifelong process; 2) design is always evolving; and 3) resources are limited. Of the six principles, five speak directly to elements of sustainable design. The principles for learning environments relevant to this paper are listed below:

1) Enhance teaching and learning and accommodate the needs of learners.
2) Serve as center of the community.
3) Result from a planning/design process involving all stakeholders.
4) Provide for health, safety and security.
5) Make effective use of all available resources.

(United States Department of Education (USDE): Design Principles: Schools as Center of Community, 1998, p. 2)

Reflecting the thinking that is occurring at the national level, these principles offer clear support for the application of sustainable design practices to new school building design. Under the first principle the summary states:

> While most of the existing facilities housing the 86,221 existing public school institutions in America were designed to sustain a model of education characterized by large-group, teacher-centered instruction occurring in isolated classrooms, current knowledge and research about learning calls for new models (USDE: Design Principles, 1998, p. 2).

The summary not only calls for innovation to address new models where student involvement is more active, cooperative and project-based, it also calls for an accelerated pace for research on the impact of the physical environment on learning. Efforts in sustainable design to address indoor air quality, day lighting and acoustical needs are all methods that speak to addressing physical conditions that impact student performance.

Considering schools as centers of communities supports the concept that schools are important symbols of "place." They should be welcoming to all members of the community. Children should be welcomed into the community, not set apart in isolation. Schools should represent centers of life-long learning where community members of all ages come to learn. And, by looking to schools as centers of community, resources may be shared and conserved by creating a site that is multi-purpose and open many hours of the day throughout the year.

The third principle speaks to the use of a collaborative process to include all stakeholders in designing an environment for learning. This is important for the support this process lends to inclusion and the resulting commitment of a community to a new building. From the perspective of sustainable design, the integrated approach to multiple stakeholder participation in the concept and design phases of planning a new school results in problem solving and design innovations that support the goals of sustainable design practices.

The fourth principle, to provide for health, safety and security supports the sustainable design goal of caring for the physical health and well-being of those who will use the building. The summary for the fourth principle speaks to the need to create an indoor environment free of toxic materials. Interestingly, the summary also points out that schools should be designed to be more human-scale and personal to promote a sense of security and community. Reliance on "cookie cutter" approaches to school design across the nation has clearly been shelved as a relic of the past, no longer appropriate for today's learning environment.

> Attractive, well-designed and well maintained facilities communicate respect for the people and activities housed in them. As such, they contribute to positive school climate, good discipline and productive learning. (USDE: Design Principles, 1998, #4).

In stressing the importance of making effective use of all available resources, the fifth principle raises the point that school designs must not only be built for people, but also for the environment. Conservation, preservation, and low-impact use of mechanical and energy systems are all recommended as features that should be part of any design. What are some of the specific elements of sustainable design for schools? A discussion of those elements follows.

Elements of Sustainable Design

The goal behind a new approach to built school environments is multifaceted. An essential component is to integrate a school building's design with the goals for learning while simultaneously recognizing the interdependency of the built environment and its occupants with the natural environment. Attention to this essential component will lead to design that promotes the physical and emotional health of the occupants and supports – rather than works against – a student's ability to learn.

In addition, a building, simply by the nature of its design, may be used as a concrete symbol of learning. A building designed on the premise of our link to and interdependency with natural systems is a statement of our respect for the environment and of our accepting responsibility to care for the environment through deliberate and thoughtful design decisions. Concurrently, by creating a healthy and productive work place and an operating facility that is cost effective to maintain, we recognize the importance of meeting the social, emotional, physical and economic needs of a community.

A school's built environment includes the outer shell of the building, the systems and materials that go into making the building a safe and protected shelter, and the sites, landscapes and cultural settings into which the building is placed. The built environment is designed with consideration for the environmental quality of elements that are identified and integrated into the plan.

The following discussion of those elements provides an introduction to the range of considerations for environmental quality in sustainable design. It is not a comprehensive instruction of how the elements may be technically applied to design and construction.

Buildings resemble ecosystems. They are complex assemblages of interwoven, interacting elements (Rosenbaum, 1999). Traditional schools have been viewed as structures of "brick and mortar" that are designed and constructed under the direction of facilities' managers, that are maintained by custodians and that are used passively by students, teachers and staff. (Center for Environment, Education and Design Studies, 1999). Under that philosophy of design and operation the elements of a building and site are broken into component, isolated strategies and systems that are intended to compliment one another actually may end up working against each other.

If more attention is devoted to integrated design during the initial design process, then the potential for realizing cost savings during construction and, over the long term, in operations and maintenance is significantly enhanced. In the article "Little Green Schoolhouse" Tremain notes that

> ...architects and engineers who set out by viewing a building, its landscape, and functions as a whole might arrive at the cost-saving idea of having solar collectors serve double duty as sound barriers. Or they might translate marginally higher up-front costs such as natural lighting into significantly reduced over-all costs (1999, p. 19).

Commonly, after salaries, a school's largest expense is operating costs. In fact, the U.S. Department of Energy estimates that schools could save $1.5 billion annually, a quarter of the nearly $6 billion spent to cover operating costs, by "greening" themselves (Tremain, 1999). Using sustainable design practices, Gary Bailey, whose North Carolina firm, Innovation Design, is a national leader in creating green schools, calculates that the schools his firm designs run 30,000 to 45,000 BTUs compared to typical schools that run around 100,000 BTUs per square foot. Using the Department of Energy's BTU figures the annual yearly savings could be as high as $4 billion (Tremain, 1999). ("BTU" stands for "British Thermal Unit and is the standard of measure used to calculate energy consumption.) The important point behind the number crunching is to realize that a sustainable design approach to building offers the potential for tremendous savings. For cash-strapped school districts, that potential alone presents a strong argument to consider sustainable design practices in planning for new school construction.

As described in Chapter V, planning for the Sakai Intermediate School included specifications that a salmon-spawning stream flowing through the site was to be protected. Because this specification was built into the planning, design and construction phases of the project, problems with the original siting of the school were identified early. Modification to the siting and drainage designs were made early enough in the project to keep to the original goal of protecting the onsite portion of the stream. With a coordinated, integrated approach, despite the complexity of systems in a project of that scale, the challenge to protect the stream was dealt with in the most efficient economic way - at the front end of the project. It is critical that any sustainable design be based on collaborative, interdependent communications between all stakeholders involved with the project.

Using the same premise of integrated planning, school districts that are faced with building multiple schools can save money by developing a prototype for building. Hopefully, a prototype does not spell "rubber stamp schools," but instead reflects goals for materials use and performance standards that are then translated to be site appropriate. Bailey describes his own experience:

> I recently visited Clark County, NV, the fastest growing school district in the country. They are planning 80 new schools. I told the superintendent about our experiences in North Carolina and Texas. I showed him how, for an investment of $200,000 to develop prototypes, he could save millions. He was initially reluctant. But he left convinced" (Tremain, p.1999, p.19).

Given the importance of applying an integrated approach to planning, what are the key components of sustainable design? In her 1999 article entitled "Little Green Schoolhouse" Kerry Tremain borrows from Bailey a list of thirteen rules for sustainable design (1999). While those "rules" do not necessarily represent a comprehensive list, they touch on the main areas that are components for consideration in sustainable design. Table 1 represents a modification of the elements listed in Tremain's article. Table 1 includes a listing of additional elements and it is organized by category to highlight important sustainable design functions.

An additional and very important consideration for sustainable design is the plan to manage the construction process. While the elements listed for sustainable school design obviously impact construction decisions, it is important to address the issue of impacts from construction up front. Looked at nationally,

Table 1: Elements of Sustainable School Design

1. Site Preservation
   - Site planning and landscape design. Maximize the site's natural conditions and design easy access for pedestrians, bikes, mass transit, etc. Provide site protection during construction.
2. Building Enclosure
   - Energy-efficient building shell. Design shell to address energy flows and use windows to maximize winter solar gain while minimizing summer overheating.
3. Resource Conservation
   - Energy systems. Consider the wide range of viable passive energy technologies and integrate them into overall design for maximum effect.
   - Water conservation. Harvest rainwater; use low-flow fixtures and native plants.
   - Environmentally sensitive building products and systems. Consider the life-cycle energy of materials and processes; prefer local, recycled, non-polluting materials.
   - Recycling systems and waste management. Encourage contractors to recycle, and to design buildings to facilitate staff and student recycling.
   - Transportation. Use alternative fuel and solar electric vehicles; discourage single-car travel.
4. Interior Quality
   - Air Quality: Use non-toxic or low-toxic materials and use natural or high quality mechanical ventilation systems.
   - Day-lighting. Orient buildings to maximize southern exposure; use daylighting to illuminate classrooms and reduce related energy costs.
   - Acoustics. configure building massing, forms and building group relationships to reflect and dissipate sound.
5. Operations and Maintenance
   - Commissioning and maintenance. Recognize and design for ongoing efforts. (Commissioning is a process to bring a building into operation by testing building systems (mechanical, electrical, plumbing, irrigation, etc.) to insure they are designed, installed and functional according to the agreed upon specifications. Commissioning may occur during design specification, construction and once the building is completed and occupied.)
6. Education
   - Eco-education. Design the school as a teaching tool for sustainability and send the message that it matters.
7. Community
   - Work with the local community to capture the historical, cultural and environmental importance of place.
   - Collaborate to design the school to function as a center of community.

again given the scale of need for school construction and renovation, the potential impacts from the construction process are immense. Kibert recognizes that impact in the following statement.:

> The construct of human society designed to allocate and provide resources to people is the economy, which, at least for the production of material goods, depends almost entirely on nature for its energy and physical inputs. The built environment is a major sector of the economy and to be sustainable it, like every other sector of activity, must examine its behavior in light of the imperatives and constraints dictated by sustainability. The unsustainable use of land, energy, water, and materials that is characteristic of construction industry must be changed from the present-day open-loop, cradle-to-grave model to a closed-loop system integrated with an overall industrial system that focuses on dematerialization, deenergization, decarbonization, and detoxification (1999, p.1).

Susan Maxman, of Susan Maxman Architects, points out that "the construction industry continues to have a major environmental impact, generating at least 20 percent of the nation's solid waste, consuming more than 11percent of U.S. energy, and producing 30 percent of the country's greenhouse gases" (Zeiher, 1996, p. 42). Largely because of that observation, she chose to focus her work on design for the environment, or sustainable design. As both Maxman and Kibert observe, it is important to recognize that sustainable design is about both design for environmental quality in a building and about the impact of that design on the construction process.

Overview of the Process

How does a school district go about planning for new school construction based on sustainable design practices? Is the process substantially different from traditional approaches to building? One of the challenges school districts face is that many administrators begin projects with little or no previous experience in design or construction. The process can be daunting, particularly in today's world of escalating costs, tight budgets, and conflicting political agendas.

Historically, design has been determined by professionals in charge of managing budget and design processes for a building. A typical team may include the client (in the case of schools perhaps the facility manager), the architect, engineers, consultants, and contractors. In this scenario each group works linearly, passing the task on to the next group once their responsibilities are complete. Decisions are driven by cost, time and the quality of the product desired. There has, traditionally, been no link made by decision makers to "....be aware of the connections between environmental stewardship and the life cycle cost implications of long term investments in building costs" (Commonwealth of Pennsylvania, 1999, p. P3). In addition, pressure to accept low bid contracts and minimal quality standards for materials and construction techniques often ends up resulting in higher operating and maintenance costs over the life of the building.

Traditional design and construction processes for the built environment have not been created in a contextual framework with consideration for the surrounding community. A design may be submitted for public "input" but at that point in time it is so far down the road more than cosmetic changes become difficult if not impossible to manage for reasons of economic and schedule restrictions. Public forums may be prolonged and antagonistic because communications with the community come so late in the process (Pollard, 1994).

In describing the outcome of a planning process in Vancouver, B.C., Pollard comments on the importance of the initial, collaborative design charrette to guarantee sustainable practices are incorporated into a design and carrie through to project completion. (A "charrette" is an intensive design workshop that involves people working together over the course of several days.)

> In addition to underscoring the notion that environmentally sensitive approaches can be positively integrated into community planning philosophy and demonstrating this through three design options, the charrette .....underscored the critical fact that a multidisciplinary and holistic design philosophy is essential to achieving a sustainable paradigm.
>
> This arguably has been the most important point to be reinforced with this exercise. Without the equally weighted, simultaneous input from engineers, landscape architects, students, ... researchers, development consultants, planners, regulators and architects into the design process at the outset, the interrelationships and interconnections between natural, economic and built form aspects of a community would not have been fully and properly explored and exploited. (Pollard, 1999, p. 7).

A critical point of recognition, then, in any sustainable design process is that the initial stages of planning are most critical if the educational, environmental, economic and community benefits of the design are to be realized. The demands on design team time *and* the opportunities to save money are both high at the start of the design and construction planning process. They are at their highest at the point of team-building and goal setting. As the design and construction process progresses through its various phases to completion, the demand of time on the planning team and the opportunities to save money both decrease (Commonwealth of Pennsylvania, 1999).

Table 2 summarizes these steps in a list format. It is important to note that Table 2 is not intended to be a complete checklist of steps in planning and

Table 2
Sustainable Design Process for Planning, Design and Construction

1) Predesign
- Assemble Green Team
- Develop Green Vision
- Establish Project Goals and Seek Public Imput
- Establish Green Design Criteria
- Set Priorities
- Develop Performance Based Building Program
- Establish Energy and Lighting Budget
- Develop Partnering Strategies
- Develop Project Schedule
- Review Laws and Standards
- Conduct Research

2) Design
- Seek Public Imput
- Confirm Green Design Criteria
- Develop Green Solutions
- Evaluate Green Schedules
- Check Cost
- Integrate Systems
- Refine Green Solutions
- Check Cost
- Document Green Materials and Systems
- Verify Material Test Data
- Seek Public Imput

3) Construction Documents and Specifications
- Insure clear statement of design intent
- Check design intent against building rating systems
- Include performance goals for systems and materials

4) Construction Bidding and Process
- Closely consider merits of design and construction by team as opposed to the conventional, linear bidding and construction process.
- Closely moniter process to insure integrity of goals for Green Solutions

5) Commissioning
- Mechanical
- Plumbing
- Electrical
- Other

6) Occupancy
- Regularly Confirm System Performance
- Perform Maintenance
- Conduct Post-occupancy Evaluation and Continue Commissioning as Needed.

SOURCE: *GUIDELINES FOR CREATING HIGH-PERFORMANCE GREEN BUILDINGS*, COMMONWEALTH OF PENNSYLVANIA, 1999, P. P4.

building a school. To detail that process is beyond the scope of this paper. However, Table 2 is intended to provide the reader with an understanding of the scope of planning elements that are important to sustainable building and that should be used as an alternative to traditional approaches to planning, design, and construction of schools.

Summary

In its essence then, an integrated approach to sustainable design incorporates considerations for site preservation, energy efficiency, resource and material conservation, indoor air and light quality, and water quality and conservation. The entire planning, design, construction and post-construction evaluation is interdisciplinary in that all parties are involved in the sphere of the project. Goals are established early and are clearly stated. Cost analyses are built into plans to understand the pay-off between up front and longer term operating and maintenance costs. A coordinator to oversee the process is designated and supported. Table 3, a description of a "Green Building" from a publication by the Commonwealth of Pennsylvania, summarizes many of the concepts.

Randolph Croxton, an architect deeply involved with environmentally conscious office design, puts these elements into the context of sustainable design by describing the architecture of his company Croxton Collaborative:

> If one word could summarize (our) architecture, it would be "optimization," says Croxton. "There are enhanced levels of energy efficiency, indoor air quality, pollution and CFC (chlorofluorocarbons) avoidance, solid waste management, water conservation, visual comfort, light quality, thermal comfort, and an enhanced awareness of time of day, seasons, and

orientation to the sun, achieved within an overall market rate budget" (Zeiher, 1996, p.37).

Table 3: High Performance Green Buildings

- A project created via cooperation among building owners, facility managers, users, designers and construction professionals through a collaborative team approach.
- A project that engages the local and regional communities in all stages of the process including design, construction and occupancy.
- A project that conceptualizes a number of systems that, when integrated, can bring efficiencies to mechanical operation and human performance.
- A project that considers the "true costs" of a building's impact on the local and regional environment.
- A project that considers the "life cycle costs" of a product or system. These are costs associated with its manufacture, operation, maintenance and disposal.
- A building that creates opportunities for interaction with the natural environment and defers to contextural issues such as climate, orientation and other influences.
- A building that uses resources efficiently and maximizes use of local building materials.
- A project that minimizes demolition and construction wastes and uses products that minimize waste in their production or disposal.
- A building that is energy and resource efficient.
- A building that can be easily reconfigured and reused.
- A building with healthy indoor environments.
- A project that uses appropriate technologies, including natural and low tech products and systems, before applying complex or resource intensive solutions.
- A building that includes an environmentally sound operations and maintenance regimen.
- A project that educates building occupants and users to the philosophies, strategies and controls included in the design, construction and maintenance of the project.

SOURCE: GUIDELINES FOR CREATING HIGH-PERFORMANCE GREEN BUILDINGS, COMMONWEALTH OF PENNSYLVANIA, P. iii.

Laura C. Zeiher (1996), in *The Ecology of Architecture*, explains that sustainable design results "less from right or wrong solutions than from a full exploration of complex subjective issues, "sustainable design" not only respects natural resources, but also embraces human, cultural, and historical distinctions" (p. 30). Sustainable design is not a finite formula available as a cast model set in concrete. It offers a spectrum of design solutions that must fit the needs of a client, the site and the surrounding community. The key is that the spectrum of solutions work within an overriding framework that reflects a respect for resources so they are not depleted or permanently damaged. It is a process of innovation and restoration with respect to the natural environment, materials use and enhancement of human health, well-being and performance.

The Rocky Mountain Institute's (RMI) *A Primer on Sustainable Building* (1998) suggests five principles that should be considered in any use of sustainable design. First, the work completed at the front end of the design process is critical to the successful outcome of the building product. Second, sustainable design is more a "philosophy of building rather than a building style" and, as such, may be "invisible" as a building feature. It is rather, integrated into a design style which will vary according to the needs of a site and a client. Third, sustainable design, by definition, does not assume excess expense or complicated design. Fourth, an integrated approach is critical. And, fifth, minimizing energy consumption is central and should be translated into energy-efficient mechanical and appliance equipment and materials.

In building new schools, the purpose of linking an integrated design approach to sustainable design practices is to create a building of quality. The elements of a quality building mean that it is secure, durable, cost-effective, aesthetically pleasing, environmentally sound, and site sensitive. In addition, methods and practices for resource conservation are employed both during and after construction. Finally, design decisions within the context of designs for schools center on the educational goal of creating an environment that supports and enhances a student's ability to learn. Just how the elements of sustainable design may benefit a student's learning skills is the subject of Chapter Four.

CHAPTER IV

STUDENT PERFORMANCE AND SUSTAINABLE DESIGN

> The environment of a given educational facility has a considerable effect on the daily activities of those using the facility. Students, teachers and staff can't always verbalize what they like about the physical details of a building but they recognize the effect the building has on them. Research has shown that the condition of a school building definitely affects student achievement and student behavior and that there are elements of facility design that are perceived to improve the learning climate" (Maiden, 1998, p.40).

Increasingly, research is demonstrating that the quality of a building, the materials use, indoor air quality, interest-grabbing design features, use of day-lighting, acoustic designs and more, impact the performance of those who use a school building. It seems self-evident. Would we want to work in an environment that was dark, unevenly heated or ventilated, in such poor condition that we cared little about our impact on the building?

It is of critical importance that the design, planning and construction of any school be based on the understanding that the physical facility influences the occupants learning climate. A convincing argument may be made for the use of sustainable design practices in planning for new school construction precisely because that practice is so intimately tied to the whole design of a school and its siting both within a community and on a particular piece of land. By using a holistic approach to design, a sustainable design process is able to more fully consider the needs of all stakeholders who will be using the school. This approach to new school design and building stands in contrast to the more traditional emphasis on cost containment - the responsibility of administrators - and on technical design - the responsibility of architects and builders. Under a traditional scenario the idea of building to create a learning environment would most likely be stated as the goal, but the process used to meet that goal could preclude its complete success.

At the most basic, financially analytic level, we spend enormous amounts of time, money and energy investing in our schools, the staff who work in schools, and our children who attend school. We have a vested interest in keeping those who attend school for work, learning and play productive and healthy. Investments in sustainable design will pay off in improvements in performance, productivity and attitudes. Those investments are rewarded by meeting our needs on a number of different sensory levels.

Health is multi-dimensional and includes not only physical factors but also factors of psychological and social well–being. We have, as humans, basic instincts for both "survival needs" and "well-being needs." Survival needs include environmental health factors that affect human health such as air and water and acoustic levels. Well-being needs include quality of life factors that affect both social and psychological health.

There are several specific design features that are becoming recognized as important contributors to enhanced student performance and to a sense of well-being on the part of students, teachers and staff. The premise behind inclusion of those features is that the better people feel about their personal health and their work environment, the more able they will be to work productively. The following discussion explores the features that translate into positive results for school occupants. Those features include daylighting (use of natural lighting), acoustic design, attention to materials and mechanical systems that affect air quality and incorporation of natural environment features.

Lighting

Adequate lighting is an important feature of any learning environment. If lighting is insufficient, students will be less able to perform "visual learning tasks" (Maiden, 1996, p. 42). On the other hand, lighting that is too intense may interfere with the learning environment by creating uncomfortable situations with excessive glare and/or heat. Considerations of lighting, therefore, become not just an issue of how much, but also of what quality. Quality of light is related to brightness, width of spectrum and glare (CAE: Does Design Make a Difference?, 1997). Quality is impacted by not only the source of lighting but also by the finishes of interior spaces. How is the quality of the light impacted after interior spaces are painted and include other interior finishes such as flooring and furniture?

In an article entitled "School Sense," Üllik Rouk states that: "The effect of lighting in a learning environment has to do with a lot more than students' visual comfort. There is mounting evidence that lighting also affects student behavior, health, and academic performance" (*Probe*, 1997, p. 41). This attitude toward lighting, and in particular daylighting, did not always prevail. For many years, particularly during the energy crunch in the 1970s, schools were designed without windows. The goal behind this design was to save energy, reduce vandalism and remove outside distractions from student views. Districts reasoned that windowless buildings would stay cooler, demand less energy for cooling and, thereby, translate into budget savings.

Subsequent studies showed that windowless classrooms were more of a deterrent than a benefit to student learning. For example, rather than being a distraction to students, "transitory window gazing" actually offers benefits from what is described as "soft" attention. Students will seek a break from attentive listening by perhaps doodling in a notebook. This is considered a "fixed focus activity." According to Rouk, it is much easier for students to refocus their attention on the teacher after a few moments of soft attention than it is after engaging in activities that require a more pointed focus (*Probe*, 1997).

The first research on the positive effects of light occurred in the early 1980's. More recent research by the Alberta Department of Education, from 1987 to 1991, considered the affect of different lighting schemes on the health of children. The study compared differences in the health of children in rooms with full-spectrum florescent light, full-spectrum florescent with ultra-violet enhancement, cool-white florescent, and high-pressure sodium vapor (HPSV). Full-spectrum light, although still artificial, has all the spectrum characteristics provided by daylight, including vitamin D, an essential nutrient for growth. According to the authors of the study, because the other three schemes are less than full-spectrum, their benefits are compromised.

Although several sources refer to the Alberta study without raising any question about the methods used for study controls, the text of the Alberta study that this author read did not specify the controls used to insure the validity of the study's conclusions. However, the results that were put forth do indicate a benefit of full-spectrum lighting schemes over other more limited spectrum schemes and, in particular, the HPSV scheme. Under full-spectrum light students attended school 3.2 more days per year, had less tooth decay, showed more growth gain in height over a two-year period, and achieved better academic performance than students attending schools with other lighting (Hathaway et al., 1992).

Rouk describes another study conducted in the latter part of the 1990s by Michael Nicklas and Gary Bailey of Innovative Design. They compared student achievement in three middle schools they had designed for a county in North Carolina to achievement scores in other schools in the same county. Achievement was measured by using two different standardized test scores from the years 1987/88 to 1991/92 for one test and 1992/3-1994/5 for a second test. Results between the two testing systems were not compared. In addition the authors noted that, to minimize the problem of false comparisons, relative (percentage) improvement within each school was used for significant comparison, not the actual average scores between schools. Nicklas and Bailey found that students in classrooms with large windows and skylights that let in natural light outperformed other students in their school district by five to fourteen percent on end-of-grade tests. (Nicklas and Bailey, 1995).

The Innovative Design study looked specifically at the benefits of daylighting because more people are coming to the conclusion that natural light is an important part of school design. It has two benefits that are significant to the management of a school district: It helps to minimize energy use and increase performance and productivity. In a separate study of the daylit schools' energy performance, Nicklas and Bailey concluded that the daylit schools used 22 to 64 percent less energy than non-daylit schools. They also noted that the payback on all the new daylit schools was below three years, a significant benefit to the school district (Nicklas and Bailey, 1995).

Additional research continues to document these benefits. The CAE article entitled "Does Design Make a Difference?" (1997), describes the results of a study conducted by Paul Grocoff, Ph.D., to measure impacts of different lighting environments on student behavior and perceived behavior. The description of his results does not include any detail about the size of the study, the parameters and controls, or a clear definition of the terms used to describe student and teacher behavior and reactions to the varied lighting environments. The summary description does, however, serve as an indicator of how students and teachers may respond to varying levels and qualities of light intensity.

Grocoff found that under the lighting systems he tested the students felt "the worst" under the traditional classroom lights – those with warm white fluorescent lamps at a power of 3000 kilowatts. The teachers also felt their behavior was "not at its best." The students felt "the best," and the teachers felt they behaved at their best, under the skylights, or natural lighting. The students found the natural light to be "comfortable," and the teachers appreciated the low glare, good color rendering, and good behavior demonstrated under the conditions created by skylights (CAE, 1997, p.16).

Daylighting, allowing natural light into buildings through use of windows and skylights or other specially designed means, offers many benefits to schools. Research documents improved student performance and significant energy savings – up to 50 percent according to Barbara Ervine of Lighting Design Lab (Ohrenshall, 1999). Daylighting helps fulfill emotional needs for a connection to natural environments by allowing visual viewing. It enhances colors, renders them more effectively to the human eye. By paying attention to lighting, provisions for daylighting and glare control, school communities will be more successful in designing a school that, through conscientious design decisions, supports and enhances the learning environment.

In August 1999, a rigorously documented study looking at the effect of daylighting on human performance was made public. The study, entitled "Daylighing and Productivity Study," was sponsored by Pacific Gas and Electric Company and conducted by the Heschong Mahone Group. The study looked at "the effect of daylighting on human performance and focused on skylighting as a way to isolate illumination effects from other qualities associated with daylighting from windows, such as view and ventilation" (Heschong Mahone Group: Condensed Report, 1999, p. 4). Rigorous controls were used to insure the quality of the data collected. Careful analysis was conducted to select the grade levels and schools to use for the study. Elementary schools were chosen from three school districts in different regions of the western United States. Math and reading test scores were analyzed for over 21,000 students from those districts.

In Seattle and Fort Collins school districts, scores from the end of the school year were measured. Scores for a third district, in Colorado, were measured over a school year to track the amount of change from the beginning of the year. A summary of the findings follows:

> Controlling for all other influences (in the Colorado Capistrano school district), we found that students with the most daylighting in their classrooms progressed 20% faster on math tests and 26 % on reading tests in one year than those with the least. Similarly, students in classrooms with the largest window areas were found to progress15% faster in math and 23% faster in reading than those with the least. And students that had a well-designed skylight in their room, one that diffused the daylight throughout the room and which allowed teachers to control the amount of daylight entering the room , also improved 19-20% faster than those without a skylight. ...students in classrooms where windows could be opened were found to progress 7-8% faster than those in rooms with fixed windows.
>
> Students (in Seattle and Fort Collins) in classrooms with the most daylighting were found to have 7% to 18% higher scores than those in rooms with the least.
>
> The three districts have different curricula and teaching styles, different school building designs and very different climates. Yet the results of the studies show consistently positive and highly significant effects. This consistency supports the proposition that there is a valid and predictable effect of daylighting on student performance (Heschong Mahone Group, 1999, p.2).

The question of *why* natural lighting improves student performance is not documented. What is it about daylighting that might cause such an effect? The authors of the "Daylighting in Schools" study offered a number of different informed guesses. They are listed below.

1) Improved visibility due to higher illumination levels
2) Improved visibility due to improved light quality, including better distribution of light, better color rendition, absence of flicker and sparkle or highlights on three-dimensional objects.
3) Improved health
4) Positive occupant response due to decreased daylight deprivation
5) Improved mood

6) Higher levels of alertness
7) Improved behavior

In the past, schools have often used a standard layout of artificial lighting to illuminate classrooms and other areas of school use. Now, in keeping with the principles of sustainable design, it is important to create lighting plans that are suited to individual schools, sites and locale. Lighting requirements will vary significantly across the nation from Florida west to the Pacific Northwest and beyond to Hawaii and north to Alaska. Schemes to use daylighting will also vary depending on the hours of direct available daily sunlight and the intensity of that sunlight in each different locale. The influence of daylighting and artificial lighting has been documented. The challenge for school districts is to take that information and fit the design to meet the needs of their school sites.

Acoustics

Another design feature that impacts student learning is acoustics. Because younger children learn language through hearing sounds, it is important that acoustics designs account for this need by designing spaces that will meet noise level standards. This need is also relevant in environments with hearing impaired children. For those children poor acoustic design that results in noisy, reverberant classrooms may create barriers to learning or, in other words, a barrier to educational access. A major source of noise levels are heating, ventilation and air conditioning (HVAC) systems and insufficient or poor use of sound-absorbing materials.

A report by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), April 1999, includes summaries from three people who spoke at the conference about the effect of acoustical barriers in the classroom. Peggy Nelson noted that typical classrooms often have background noise levels between 35-45 decibels. The high/low range corresponds to whether the HVAC system is on (high) or off (low). When the rooms are occupied the decibel numbers rise to 58-62. Based on acoustical studies this range is considered to result in poor hearing conditions. For comparative purposes, and to better understand the impact of the higher decibel numbers, it is interesting to note that the City of Seattle assigns a noise standard of sixty decibels to commercial use areas (Saperstein, 2000).

Nelson also notes that a study of an acoustics condition rating index shows that the age of listeners has little impact on score results when acoustics are within an acceptable decibel range. However, when conditions swing to the higher noise levels, the ratings index drops for younger children compared to adults in the same space. This suggests that younger children have a harder time comprehending and listening when background noise levels are too high.

Another speaker, Sigfrid Soli, supported the claims of Nelson by concluding that low-background-noise environments provide a "level playing field" for many (if not all) students. In contrast, high-background-noise classrooms impose barriers to hearing for a range of students. Because a child's ability to sort "signals" from among noises is not fully developed until teenage years, the ability to learn is compromised by ambient background noise. Soli listed a number of factors that, through a calculation of decibel "penalties," create poor hearing conditions for children. Those factors are age, hearing status, lack of language proficiency, ranges of individual differences in hearing and excessive reverberance in a room. For any one of those factors, higher noise levels exacerbate the ability of children to learn. Combine those factors into one room and the result is to severely compromise a child's ability to learn.

According to the report, new federal rules are likely to be developed in the year 2001 in response to complaints regarding poor classroom acoustics and the obstacles to learning those classrooms present for hearing-impaired students. The article suggests that those regulations, if implemented, are likely to change design approaches to the selection of HVAC systems. Interestingly and particularly relevant to sustainable design practices, one of the speakers, Jerry Lilly, spoke directly about the contribution of HVAC systems to classroom noise. He was quite clear in stating that low-first-cost HVAC systems will result in problems. The implication, then, is that if HVAC systems are to be used, consideration of the impact on all school operations must be weighed against the purchase and installation costs.

Air Quality

Between the ages of 5 and 18 a student may spend 14,000 hours inside a school building (Environmental Defense Fund, 1999). Recognizing the amount of time children spend indoors, it is important that the air quality in schools be good. In addition, according to the American Academy of Pediatrics, children are more severely affected than adults by air pollution. "Air pollution affects children more than adults because of their narrow airways, more rapid rate of respiration, and the fact that they inhale more pollutants per pound of body weight" (Environmental Defense Fund, 1999, p. 1). Air quality, then, is another factor for the school community to consider in order to create a school with a healthy environment for the children and adults who will use the facility.

Similar to the 1970s decision to eliminate windows as one means to reduce energy costs, school officials also sealed the buildings tightly to reduce air flow that might increase the need for energy expenditures. This decision resulted in air quality problems for schools because ventilation was reduced and pollutants sealed in. The U.S. General Accounting Office acknowledged this problem by reporting in 1995 that more than half the nation's schools had experienced indoor air quality problems (Environmental Defense Fund, 1999).

Any new school building must be designed with careful consideration to assure a high level of air quality. Problems that are not anticipated can result in expensive repairs for school districts. The Bainbridge Island School District, for example, experienced air quality problems in some of its schools and, as a result, specifically included air quality performance standards for a new school building in order to avoid similar problems. Their experience is described in the next chapter.

In an Environmental Defense Fund article entitled "Making Our Children's Schools Safer and Healthier" (1999) several steps are listed to suggest methods for achieving better air quality in schools. Suggestions for new construction include minimizing exposure to toxic materials through careful selection of furniture, paint, adhesives, floor coverings and supplies and providing high quality systems for ventilation.

An article in *School Planning & Management* (1999) warns about the national escalation of allergies and asthma among children. The article describes the problem as a "national crisis." Although the article points primarily to old and decaying schools as the major source of the problem, it also points out that, although outdoor pollution has improved over the last 20 years, pollution levels indoors have increased. These factors make it imperative for schools to pay careful attention to the design and use of HVAC systems.

Well-Being Needs

Up to this point, the discussion has centered on particular environmental hazards that, if not addressed in planning for new school construction, can reduce the quality of a building's environment. Because communities and the schools within them are so intensely invested in the children and adults that use the facilities, it makes sense to create a building that keeps people productive and healthy. In a paper entitled "Toward a General Theory of the Human Factors of Sustainability," Heerwagen, Winn and Hase (1999) argue that those features are necessary but not totally sufficient to generate

> the kinds of positive impacts envisioned in the green building community....we argue that successful green buildings will integrate sustainable technologies with design features that sustain human emotional, social and cognitive needs (p. 1).

The authors use the terms "well-being needs" as opposed to "survival needs" to frame their argument. They borrow the terms from a 1971 article by S. Boyden entitled "Biological Determinants of Optimal Health. Survival needs deal with aspects of the environment that directly affect human health, such as clean air and water. Well-being needs relate to quality of life and psychological health. Because so much attention has been given to environmental factors that affect survival needs, the authors focus their attention on the benefits to organizations of incorporating into their building plans well-being needs, or the "psycho-social components of health." Although their study is not specifically centered on schools, its arguments are easily transferred to a school environment.

The authors argue that if sustainable building practices, (they use the term "green building practices"), are aimed at influencing health in a comprehensive way, then the notion of health as multi-dimensional must be recognized. Human health is multi-dimensional in that it has physical, emotional and social components. Sustainable design and green-building discussions have centered most commonly on the physical components of health. The authors document research from a diversity of sources and note that there is a common thread of understanding that might be best described by borrowing the concept known as "biophilia." Biophilia refers to "humanity's innate attraction to and affiliation with nature. Taken as a whole, this diverse body of research suggests that buildings which incorporate features of preferred natural settings will be more supportive of human well being than settings which lack these features" (Heerwagen et al., 1999, p.2).

If we consider that buildings are habitats for people, though admittedly children and teenagers may not choose schools as their preferred habitat, then, by extension, it makes sense that people will choose the "habitat" that is most suitable to their survival. They will gravitate towards a "preferred environment." The authors, using references to support their argument, provide a table that lists habitat and natural feature attributes of preferred environments. It includes "key dimensions" such as "prospect" or the ability to see into the distance, "refuge" or a sense of enclosure or shelter, and "vegetation" that includes large trees with spreading canopies for refuge and shade, flowers and shrubbery (p. 4).

The authors' argument makes a link between nature and preferred environments and the resulting outcome of "positively toned emotions" on the part of people who work in buildings with preferred environment attributes. In other words sustainably designed buildings, if they take into consideration natural habitat attributes along with attributes that promote physical health, can positively influence well-being and productivity.

> A significant body of research compiled by Alice Isen and her colleagues at Cornell University (Isen 1990;Isen et al 1987) have found that positively toned emotions can have surprisingly strong impacts on cognitive performance. Positive moods facilitate creative problem solving, decision strategies on complex tasks, discriminative learning, and memory. Although the exact mechanisms by which these cognitive effects occur are not known, Isen and others (LeDoux 1996) suggest that positive moods:
>
> - generate neural patterns associated with broad searching
> - promote novel juxtapositions of ideas, concepts, and memories'
> - enable people to "break set" more readily and see additional features and associations
> - create a more complex cognitive context associated with a broadened focus of attention and greater access to materials store in memory (p. 6).

The paper presented by Heerwagen et al. argues that sustainably-designed buildings that incorporate features and attributes of preferred natural settings and nature stimuli can have a significant impact on human well-being and productivity. The authors call for further research to more specifically document the beneficial links. The studies sited and the arguments made by the authors are not school-specific so any design needs to be modified to take into account the special needs of schools and children. The benefits, however, to linking not only physical health, but well-being health to design outcomes is clear.

Schools need to address the health of the whole child as well as the health of adult employees. Believing that health is multi-dimensional, physical, emotional and social health are all factors that need to be included in making deliberate design choices for a school building.

CHAPTER V

MAKING IT HAPPEN: THREE PROJECT DESCRIPTIONS

Planning for and studying about sustainable design does not necessarily translate into the design and implementation of a project that meets all of the anticipated requirements of sustainable design goals. The realities of time and budget restraints as well as the political support behind a project will more often than not result in compromises to the design process. School districts faced with shrinking levels of government funding and contentious operating environments may be hesitant to try new approaches to building. Knowing this, and despite the risk of breaking new ground, many districts have studied the positive results offered by sustainable design and subsequently chosen to embark on building campaigns that embrace that design philosophy and application.

This chapter includes descriptions of sustainable design projects from three different school districts. The descriptions provide the reader with real-life examples of how sustainable design principles may be applied to new school buildings as well as observations about some of the challenges and rewards school districts may encounter in carrying out sustainable design projects. The three schools discussed in this chapter are the Sonoji Sakai Intermediate School in the Bainbridge Island School District (Washington), the Roy Lee Walker Elementary School in the McKinney Independent School District (Texas) and the Newport Coast Elementary School in the Newport-Mesa Unified School District (California).

Three primary means to gather information about the school projects were used in researching this chapter. Research was conducted on the Internet, managers for the projects were interviewed and, in the case of Sakai Intermediate School, a site visit was made. Interviews were conducted using the list of questions included in Appendix B. Interviews were conducted by phone, e-mail or in person.

It is important to note that the following descriptions are intended as overviews of the projects. In all cases, only one to three participants in the projects were contacted. In the case of the California school project, information was gathered exclusively through discussions with the project manager from Southern California Edison, the utility responsible for coordinating energy efficient-designs with the school district. Although particular features are highlighted in the descriptions, they are not analyzed in depth. Certainly, each project is of enough interest and value to deserve a comprehensive case study. It is not, however, within the scope of this paper to offer that depth of investigation and analysis.

SONOJI SAKAI INTERMEDIATE SCHOOL

Sonoji Sakai Intermediate School (Sakai), constructed over the course of 1998 and 1999, is a fifth/sixth grade school that was occupied in January 2000. It is located in the Bainbridge Island School District (BISD) in the state of Washington. Bainbridge Island is located in Puget Sound, a 35-minute ferry ride west of downtown Seattle. The Island is connected to the Kitsap Peninsula on its north end by a bridge that spans a quarter mile waterway, Agate Pass. Bainbridge is approximately seven miles long and covers an area close to 20 square miles. It has a year-round population of approximately 20,000 people.

Responding to a growing influx of families to the Island, BISD has built two new schools and remodeled portions of all the other District schools within the last five years. The Sakai Intermediate School is the latest school to be built in the district. With its completion, the District now includes three elementary schools, the intermediate school (Sakai), a middle school (grades seven and eight), a High School and a number of K-12 optional programs. Approximately 3600 students are currently enrolled in the District's schools.

The BISD experienced serious air quality problems in one of its previously built schools and stream and watershed damage at another school site. The School Board was therefore highly sensitized to the need for respecting environmental planning in setting its goals for the Sakai project. The School Board sensitivity was strengthened as well by the knowledge that the Sakai school site included a stream that was affected by the federal designation of salmon as an endangered species. Based on its previous experience and the knowledge of existing conditions on the Sakai building site, the School Board set three specific environmental goals for the site and building design. Those goals were: 1) to insure that ecosystems on the site were minimally impacted; 2) to insure a high quality of indoor air quality in the completed school and; 3) to employ resource conservation where sustainably designed materials and practices were used and followed during construction and in the completed building.

Planning for the new school began in April of 1997. The approach to the project was fairly traditional in that it followed the normal building progression calling for schematic drawings, design development, construction documents, bidding and contractor awards, construction and post-construction evaluation and follow-up. Unlike traditional projects, however, the level of coordination by Richard Best, the Capital Works Director, was much higher. Best was hired, in part, because of his previous work with environmentally sensitive projects. He was a champion for Sakai and managed the project to include collaborative meetings and dialogs with the various groups who would be responsible for designing and building the site as well as those who would be occupying and using the building.

In June of 1997, one year before the planned ground breaking for the school, a program planning team was appointed. The Team included representatives from the teaching and administrative staff for the new school and the school administration. The Team met with the architects in their Seattle offices as well as with various representatives of the Bainbridge community, including school staff and residents of the community. The team also met with federal grant makers to explore possibilities for funding a "teaching project" for students to learn about the priority assigned to environmental goals for the building project. The Team was asked to consider future use of the building, taking into consideration the use by community as well as the possibility of Sakai being used as an elementary school five to ten years into the future. The Team was coordinated by Best to maintain consistency with the overall planning process and to insure the goals of the planning team were incorporated into the building design.

As Capital Works Director, Richard Best was responsible for the overall management of the project. As part of those responsibilities, he monitored the project to insure the three environmental goals targeted by the District remained in the forefront of the design and building process. In keeping with those goals, he tracked site development, construction practices and specification of materials and mechanical systems. The following discussion summarizes some of the sustainable design elements used in the project to meet the District goals during the design and construction of Sakai. The summary serves as an example of how goals for sustainable design may be put into practice. The elements are listed by number and are identified by use of the category headings from Table 1, page 39.

1) Site Preservation (Minimization of Sedimentation Flow): During site development, construction was phased to protect the on-site watershed and salmon habitat by minimizing sedimentation flow. Seeding of the site perimeter to

hold loose soil was completed prior to initiation of building construction. Paving of the outer areas was completed next, to create building stage and worker parking sites, thereby avoiding excessive mud and pooling of water and silted runoff caused by the heavy use of construction equipment. The asphalt paving created a "moat" around the perimeter of the building and building pad to contain sedimentation. Three sedimentation ponds were built to filter and distribute the final flow of storm water runoff into undisturbed natural areas within the watershed buffer areas.

2) Site Preservation (Watershed Protection): In addition to concerns of impacts from construction, attention was also directed toward the impact of the building itself on the stream and watershed. Analysis by a geotechnical engineer revealed that the building, as sited, would act as a dam to the groundwater that flowed into the ravine and stream and could, consequentially, create conditions that would adversely impact that portion of the watershed. In response to this analysis, and to avoid potential adverse impacts, an interceptor trench was designed and built around the building to collect groundwater and disperse it to replicate the natural site flow and, thereby, protect the wetland area associated with the watershed.

3) Site Preservation (Contaminant Control): The BISD applied another environmentally sensitive practice to the Sakai project by adopting a strict "no pesticide rule" for the school because of its proximity to the salmon stream. This designation is even more stringent than the District's current policy which requires use of "integrated pest management" (IPM) at all its schools. (An IPM

policy states that pesticide use will be avoided whenever possible.) To further mitigate any possible harm from contaminants, areas with asphalt pavement were designed to drain into three catch basins where the water was then reintroduced to filter through a lawn area prior to entering the sedimentation pond. This option was chosen as a more ecologically friendly approach and a more effective solution in contrast to piping the water directly to the sedimentation ponds.

4) Site Preservation (Protection of Natural Vegetation Cover): A community review of the site development plans raised concerns about potential negative impacts to the site that could result from extensive soil cuts around the sedimentation ponds. The cuts were made to achieve the correct grading slope. Citizens were concerned that the severity of the cuts would result in loss of natural vegetation cover and cause, because of the loss of a canopy cover to provide shade, increases in watershed temperatures. Those increases could potentially harm salmon. In response to the concerns, plans were made to replant native vegetation extensively around the ponds and to monitor, over time, the water temperature at both the pond and at the point of outfall from the pond.

5) Quality of Interior Building Environment (Air Quality): To insure that goals for high levels of indoor air quality were met, Best specified that the higher performance Canadian air standards (20 cubic feet per minute of outside air per occupant) be used instead of the U.S. air standards (15 cubic feet per minute of outside air per occupant). A number of different methods were used to meet IAQ goals with the intent that the cumulative effect of those methods would result in a

high level of air quality in the completed building. To assist in meeting that goal a consultant was hired to provide and write detailed specifications of material use standards for the project.

The specifications for low toxicity or non-toxic materials were, for example, built into plans for purchasing furniture, carpets and basic building materials such as gypsum board. In addition, recycled content percentages were specified for many of the building materials. Extensive testing was done on paints, adhesives and caulks to insure non-toxicity. The mechanical venting and filtration system for the school was built above standard, again to support goals for IAQ. In addition, the mechanical system was designed to be located as a walk-in, easily accessible room to allow maintenance to occur on an ongoing, efficient and consistent basis.

Efforts to achieve high standards for IAQ met with success in the initial testing upon school completion. In the thirty-day off-gassing period air quality measures were below industry allowed levels by up to 84%! (Off-gassing is the period of time set aside to leave a new building up and operating before occupancy occurs to allow dispersal of toxins from materials used in the building.)

6) Education: Using the school as a learning tool in and of itself became another goal of the project team and, in particular, the teachers on the team. A small government grant was received to create two signs to describe the environmental features that were consciously built into the design and construction of the school. The grant also supported curriculum design to create

learning tools to teach the Sakai students about green-building topics such as sensitive site development, integrated pest management and resource efficient buildings. The goal behind the curriculum design was twofold. First, it was to help children become familiar with the environmentally friendly aspects of the Sakai Intermediate School. Second, it was to inform teachers and parents about various concepts of sustainability that were integrated into the design and construction of the school.

7) Community: The Sakai project captured the importance of place in the naming of the school and in a stone sculpture that was designed and made for installation in the school's courtyard garden. Sonji Sakai came to Bainbridge from Japan in 1915 and started one of the Island's early farms. During World War II, Sakai and his family were interned in relocation camps for four years. He returned to the Island and, with his wife, raised six children, all of whom graduated from Bainbridge High School. He was grateful for the education his children received and showed that gratitude, in part, by a providing land for one of the District's schools at a nominal cost. The Japanese American community on Bainbridge Island designed and donated a garden for an inner courtyard at the school and a large stone from the original site was included in the garden design.

Observations

Sakai Intermediate School was designed to meet specific goals for environmental health and resource conservation. Leadership at the top was critical to insure that the project met stated goals. The project was championed by the School District Board. It was also championed by the project manager, Richard Best, and supported by a committed group of project planners and coordinators. Coordinated planning led to a clear statement of goals that were visible throughout the project to insure continuity of actions. Budgets were clearly set and managed. Specialists and consultants were used to help with technical aspects of sustainable design. To move incrementally towards achieving environmental goals, performance indicators were built into specifications to give contractors and the builders a clearly stated direction about the quality of materials that were to be used.

With the successes, challenges also arose. Several of those challenges are summarized below.

1)Tradeoffs were discussed throughout the process. Some materials, such as the low Volatile Organic Compound (VOC) carpet, had a higher initial purchase cost but was still selected for installation because it was shown to cost less to maintain over time. (VOC's are highly toxic and include chemical compounds such as formaldehyde and known carcinogens such as PCB.) Compromises were made in other parts of the building to keep the overall budget in line with projections. For example, to reduce costs metal paneling was utilized at the gables, on the exterior of the building, to replace split faced concrete. Savings gained through that modification helped to free up funds to purchase other, more expensive materials that were deemed critical to successfully meet environmental goals for the site.

2) Although a materials specifications book was made for the project, it became apparent that it was not detailed or extensive enough to always provide clear direction for contractors or for those coordinating the project.

3) Teachers chose wall space for display purposes over more extensive daylighting. Although there are at least two large windows in each room, the decision to limit their use goes against the findings of previously mentioned studies that favor more daylighting because of its positive impact on student performance.

4) The education program for the newly configured 5th/6th grade program was not clearly defined going into the building design phase for the school and, as a result, design occurred before detailed program definition. This posed challenges and frustrations for some of the teaching staff.

5) One teacher expressed some frustration over the unknown, or less predictable factor of future enrollment projections, especially in light of anticipated population growth in the school district. Her concern, in part, related to a realization that teaching staff might lose the flexible open space areas built into the design if those spaces were needed at some future date to accommodate a growing student population.

Having completed the Sonoji Sakai Intermediate School, BISD is in a good position to build on the knowledge gained in its design and construction. With more construction likely in the future, the District has the opportunity to take that knowledge and to expand its commitment to sustainable design.

ROY LEE WALKER ELEMENTARY SCHOOL

Roy Lee Walker Elementary School is in the McKinney Independent School District in the City of McKinney, Texas. McKinney, located about 50 miles north of Dallas, has been one of the fastest growing cities in the Dallas-Fort Worth metropolitan area during the 1990s. The population of the City has doubled to 44,000 residents since the 1990 census was taken. This growth has an obvious impact on the school district. At the end of 1999, 10,900 students were enrolled. By 2003, the enrollment is projected to grow to 16,000 students. The McKinney Independent School District (MISD) has one high school facility, two middle school campuses, nine elementary school buildings, and three facilities that offer alternative education programs.

The MISD has a history of involvement with sustainable design for schools dating back to a 5.5 million dollar grant it received in 1992 from the U.S. Department of Education to design a K-12 school utilizing integrated curriculum and technology. The school, originally built as a Works Progress Administration project in 1930, was remodeled with the District intention that it be a first attempt to incorporate sustainable design features into new building. Subsequent to that work, a number of the District schools have been retrofitted for energy systems upgrades that are more cost effective to operate and environmentally responsible.

With its history of exploration and involvement, the MISD was poised to pursue sustainable design for schools in a more comprehensive manner than it had previously. In 1997, the District was one of two to receive a $200,000 grant from the Texas State General Services Commission/State Energy Conservation Office. The grant fell under a program called "The Texas initiative on Sustainable Schools." McKinney was selected from a list of 99 districts that were identified as the fastest growing districts in the state. Two other identifying factors were that the districts had bond money available for a new school but had not yet started the design process.

Having received the grant, the MISD moved ahead with plans to build a school based on the concepts of sustainable design. The project was championed by many - the state conservation office, the School Board, the school superintendent and the assigned project manager, Wyndol Fry, Executive Director of the District's Facilities/Construction Group. A conscious decision was made to integrate the design fully with sustainable practices rather than to concentrate on one particular piece such as energy efficiency or indoor air quality. Realizing they needed to learn what it meant to build a "green school," the District chose to turn to others who were experts in the field. As a result, Innovative Design, a consultant group with extensive experience working with schools and sustainable design, was hired to work closely with the district, the architect (SHW Group), engineers and the contractor.

During the course of planning, a number of different methods were used to educate District personnel and the community about sustainable design and making the planning process inclusive. District representatives, including Fry and two school principles, visited schools in North Carolina that had been designed by Innovative Design using sustainable principles. The architect held meetings to bring together a cross-section of people who would be involved with the school. Those meetings included teachers, staff, students and members of the community. The group met over three to five days to discuss the design process, their needs and the needs of the educational program. The contractor was included in the meetings from the start. The inclusive nature of the planning process was intentional to insure that all the parties with prime responsibility for managing the project or those who would be directly impacted by the project, were informed about the goals for sustainability and were given the opportunity to work for those goals from the project's inception. Meetings were held over the course of the design process and a project manager from SHW worked closely with Fry to insure that the integrity of the design documents was maintained from inception through construction.

Roy Lee Walker Elementary School is due to be completed in July 2000. The school is designed for 680 students, grades K-5. It will total 70,000 square feet and is built on a 11.3 acre site. Although intentionally designed using sustainable principles, the design itself was conceived around the needs of the educational program. The basic design represents a "finger plan," where each "finger" is a wing for two grade levels and ten classrooms. Three finger wings feed into a main building that includes a dining room, gym and library.

Specific sustainable design features included in the school plan are listed below, following Figure 2. The features are listed by number and are identified by use of the category headings from Table 1, page 39. Figure 2, a schematic illustration of the Roy Lee Walker School by the architects SHW Group, Inc., depicts the school layout and some of the sustainable features included in the plan. Note that this schematic was drawn early in the planning process and is not, therefore, an exact representation of the final plan for the school. Certain features such as the geothermal system, the amphitheater and the greenhouse were not included in the approved plans. The basic layout, showing the finger design, does reflect the approved design. The orientation of the school is towards the South.

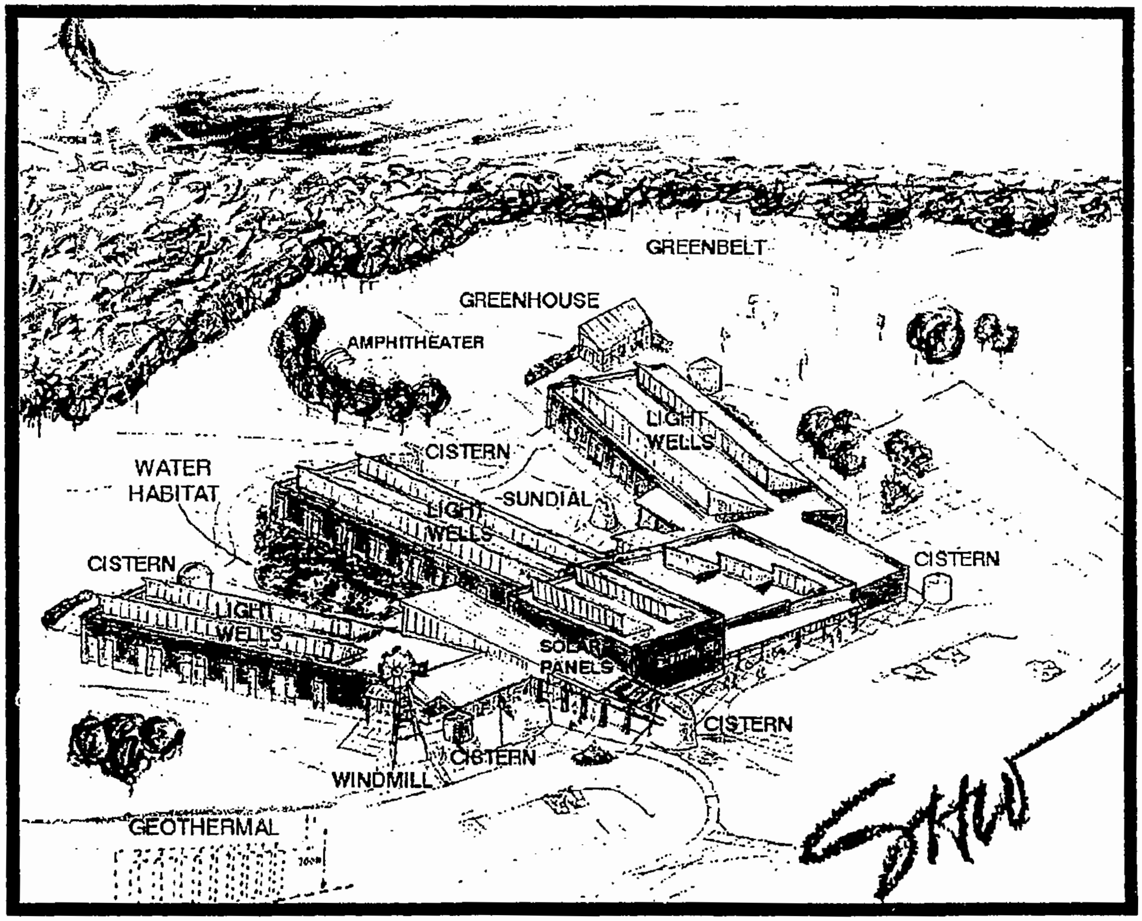

Figure 2: Schematic Drawing of the Roy Lee Walker Elementary School
Drawing provided by SHW Group Inc., project architects.

1) Resource Conservation (Energy Efficiency): The building is oriented to maximize southern exposure and minimize east-west exposure. Solar panels were installed to heat water for the school. A windmill is used on site to rise the level of water in the main cistern. Although geothermal energy systems were evaluated a decision, based on cost estimates, was made to use an efficient but conventional heating, cooling and ventilation energy system.

2) Resource Conservation (Water Usage): Rainwater is channeled through special gutters to four cisterns where it supplies water for campus irrigation. Hose bibs were built into each cistern to make the water available for use by children when they help to plant gardens around the perimeter of the school at some future date. Native grasses and plants will be used for landscaping to minimize water use and to limit mowing. Red cinders will be used on walkways instead of concrete because it is a more pervious and natural material and, unlike gravel and dirt, will not turn to mud in the rain.

3) Resource Conservation (Environmentally Sensitive Building Products) and Quality of Interior Building Environment (Air Quality): Low-toxic or non-toxic materials were specified for the project, as well as products with a high recycling content. Specifications covered use of such products as plastic laminators, adhesives and paint. Furniture and athletic products were also evaluated for their environmental health and their manufacturing efficiency in terms of sustainable practices. Site construction was managed to require separation of building material waste during construction. An effort was made to buy locally.

4) Quality of Interior Building Environment (Daylighting): Daylighting is used extensively throughout the design. Fry described it as "more than just old-fashioned skylights in the ceiling. It involves utilization of the sun to assist the lighting in the school." Light monitors "scoop" the sunlight in, bounce it off baffles, and provide evenly distributed, non-glaring daylight into learning spaces. Figure 2 illustrates the use of the light monitors (labeled "light wells). As the light enters through the monitors it is directed by rectangular shaped sheets of hanging fabric (baffles) that are hung in parallel formations to catch and evenly distribute the light. Figure 3 illustrates an interior space with the light monitors and baffles.

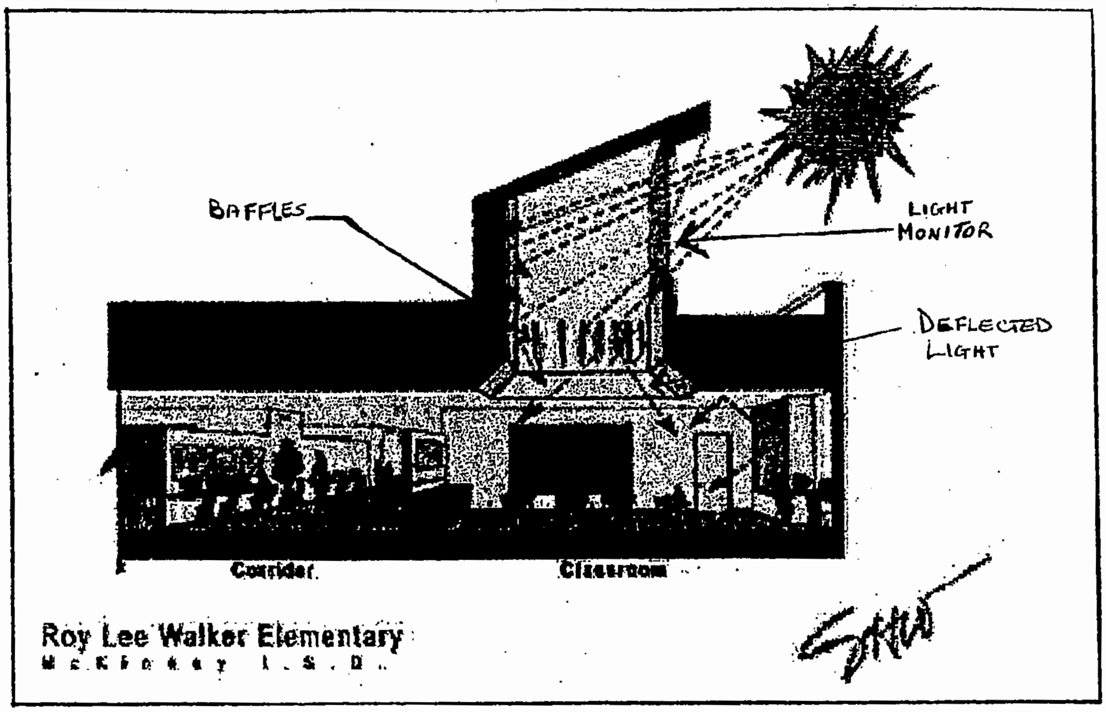

Figure 3: Interior Space Illuminated by Daylighting System
Drawing provided by SHW Group, Inc., project architects.

5) Education: Staff will receive training to learn how concepts of sustainability were applied to Lee Walker. A sundial at the gym and in the courtyard will help students learn to identify winter and summer solstices and to read time using the sun as their watch. An eco-pond, part of a man-made stream, was built for use as an outdoor habitat classroom. A hand-pump is located next to the pond. A greenhouse and outdoor amphitheater were eliminated from the budget although the foundation for the greenhouse was built. In time, the community may raise the funds to build the amphitheater.

6) Community: The school site is adjacent to a city park. The city and school district agreed to share the on-site school parking spaces and to allow the park to be used as a playground extension during school hours.

Observations

The design and construction of Roy Lee Walker Elementary School has been advertised and promoted by the School District as an important benchmark in new school design. The school received national recognition when the American Institute of Architects selected it as one of the 1999 Earth Day Top Ten award recipients in recognition of architectural design solutions that protect and enhance the environment. It represents a first effort by the MISD to intentionally design a school using an integrated and collaborative approach throughout the planning and construction management phases.

The budget for school design and construction came in higher than budgets for conventional building designs in the District. Wyndol Fry was faced with making some major cuts in materials use to eliminate one million dollars from the first bid. Daylighting was the most significant cost factor because of the steel used for construction. Alternative materials will be considered in the future. In addition, because this project serves as a prototype for the district, first time costs for planning, logistics and materials use were expected to be higher to some extent.

Fry made significant cuts to eliminate one million dollars from the budget. A large portion of that savings resulted from the elimination of daylighting in the gym. After making the cuts, because the budget was still higher than the School Board's projections, Fry had to argue further to defend the design. He successfully made the argument by explaining that initial costs should be recovered over time due to significantly reduced operating costs. Those cost savings are expected to result from the use of highly efficient applications of lighting and energy systems, resource conservation, and materials use throughout the building.

The MISD is in a unique position to test this argument because it is building two new elementary schools simultaneously, Roy Lee Walker and a second, conventionally designed and built school. The District will study the two schools over time to compare operating costs, paybacks and differences in student performance. To seek funding in support of this effort the District applied to the Department of Energy, through the Texas State Energy Office, for a two-year, $350,000 grant to run a comparison study of the two elementary schools. The study is intended to provide information about the affect of school facilities on the health and productivity of students. It is also intended to validate the need to design and build sustainable school facilities that "provide a safe and healthy atmosphere to educate our future generations." (Texas State Energy Conservation Office, 2000, p. 3). The study will be designed and administered by the University of North Texas and Texas A & M University's Energy Systems Lab. It will be interesting to revisit the District in five years to learn about the outcomes of their comparative analysis.

NEWPORT COAST ELEMENTARY SCHOOL

Newport Coast Elementary School is part of the Newport-Mesa Unified School District in California. The school district includes the cities of Newport Beach and Costa Mesa. It is approximately 30 miles south of Los Angeles and 90 miles north of San Diego. It is located in the second largest populated county in California and covers 58.83 square miles. The District originated in 1996 and currently has 22 elementary schools (including Newport Coast Elementary), two intermediate schools, four high schools, one alternative education center, and one adult education center. Approximately 21,138 students attend schools in the District.

In June 1996, the District purchased land for construction of Newport Coast Elementary, its first new school in 25 years. The land, purchased from the Irvine Company, is located in the midst of a residential development built by the company. In 1997, Southern California Edison (SCE) approached the School Board and proposed that the school be designated an energy and environmental showcase facility to demonstrate cost-effective uses of energy-efficient technology and operations. The School Board approved the proposal, leading the way towards coordinated planning and design between the architects, SCE, the District, and the community. Ground breaking for the school occurred in September 1999 and occupancy is targeted for September 2000.

The, SCE, an investor owned energy company, collects "public goods funds" from ratepayers to promote energy-efficiency as part of their regulated activities dictated by the California Public Utility Commission. The utility carries out one portion of this program through its Design and Engineering Services Group (D&ES) which is involved in showcase work with SCE customers. Deborah Weintraub, an architect by training and an employee of SCE, works with D&ES. She, with her co-worker Tony Pierce, a mechanical engineer, were the two coordinators for the energy and environmental showcase portions of the Newport Coast project. Information about this project was gathered through a phone interview with Weintraub and by reading the paper "Mainstreaming the Sustainably Designed School." Weintraub co-authored the paper with Pierce and presented it at a "Maintstreaming Green" conference organized by the American Institute of Architects Committee on the Environment and held in Chattanooga Tennessee in 1999.

Although the original intent of SCE was to support planning for an integrated, sustainably designed school campus, client concerns arose that restricted those options. The goal for the project was modified to focus on sustainable design of energy systems. To meet that goal D&ES, as coordinator for an enerrgy-efficient design, facilitated an integrated design approach for all building systems in the school to optimize energy usage and to improve the environmental performance of the school's buildings. Given the temperate climate of the school's locale, the specific goal was to reduce the need for electrical lighting while minimizing solar heat gain, using natural ventilation to achieve thermal comfort levels. Going into the project, D&ES agreed to provide a number of services to assist in both energy systems design and materials use planning. Some of those services included energy modeling and natural ventilation systems studies using computer simulation programs, a "green materials" referencing source with specifications for materials that have low- or non-toxicity content, physical modeling for daylighting, energy-efficient lighting design and controls and post-occupancy monitoring and results reporting.

A team approach for planning was used for meetings with architects, members of the D&ES group, and school district and community representatives. Certain compromises to sustainable design were made up front. For example, the architects stipulated that the building should have a physical presence on the site to the west, leaving the siting of the school less flexible in terms of planning for energy efficiencies. The developer stipulated that to maintain consistency with the visual theme of the overall development, the homeowners in the surrounding development should look down onto a red tile roof. Again, this requirement eliminated some options that may have been considered to enhance the overall energy efficiency design.

D&ES worked with a Design Committee that included teachers, administrators and parents. Members of that committee spoke to the need for flexible learning and teaching environments, systems to accommodate new computer technology, classrooms with individual control over space conditioning, good storage and "commodious" teacher work spaces. D&ES, through the Rand Corporation, ran focus groups to better understand the goals of teachers and administrators and to gauge the interest in energy and environmental priorities for the new building. In general, teachers and administrators wanted multiple means to control temperature, ventilation, lighting and daylighting systems for individual classrooms. They also looked for flexibility in furniture arrangement and technology use.

Interestingly, D&ES found that educators viewed the building as a means to demonstrate lessons on energy efficiency, but not necessarily as a resource to contribute to student learning through specific sustainable design features. "Principles did not view renewable energy as a cost savings because their schools are not considered cost centers, since utilities are billed to the district office. Principals saw the benefit as one of virtue: modeling conservation for students" (Weintraub, 1999, p. 4). Because the sample from Newport Coast was small, Rand checked the responses against a national telephone survey that was conducted in 1998 by Heery International, a research company. The results and opinions documented for the Newport Coast focus groups were similar to those recorded in the national survey (Weintraub, 1999, p. 4).

Observations

The design goal for Newport Coast Elementary School was a combination of traditional and sustainable design proposals. That factor led to a number of design compromises. The intensive participation by SCE's D&ES Group led to specific energy-efficient and sustainable design features that are integral to the overall design plan. Community participation was encouraged and facilitated to support those goals. The added benefit of D&ES's access to highly technical methods to design, test and manage energy systems was clearly a benefit. Information from the community and national surveys also were beneficial because they identified specific levels of knowledge and awareness that school administrators and teachers hold pertaining to sustainable design features and concepts.

In the concluding pages of their presentation to the Chattanooga conference, Weintraub and Pierce (1999) offer some very articulate and thoughtful comments about the challenges participants face in working with schools on goals for sustainable design. Their comments follow:

> The issues of energy use and the environment are primary issues for school design, and the Newport Coast Elementary School represents a test case of the benefits of integrating current energy modeling and analysis techniques into the school design process. It should not be forgotten, however, that other very fundamental design issues are of equal significance during this current opportunity to rethink our schools. Apart from issues of sustainable design, any discussion of new schools must include imagining the best environments for learning and for integrating developing minds into our society. ....Optimization of a campus' operations is of little value if the fundamental underlying questions on how to improve education through new school design have not been asked and discussed.
>
> Often a design project seems in retrospect to only vaguely have approximated all of the lofty intentions of the participants in the process, participants that include everyone from the architects and consultants, to the District officials, to the students and the teachers. It is always a challenge to maintain higher goals through what is often a bruising process. With the design assistance that D&ES brought to this process, an added effort was required by the design team to integrate an entirely new set of intentions into a complex process. The design team was consistently

> responsive to these added pressures, and graciously balanced competing interests when they arose. Ultimately, it is clear that without a client's early dedication to energy efficiency and environmental issues, little value can be derived from the sophisticated analysis tools used in this project. Setting a clear and widely supported sustainability agenda early in the process will go further to meeting the goal of reducing a building's impact on the earth than all of the sophisticated engineering tools used here (p. 26).

SUMMARY OBSERVATIONS

Each of the three schools described in this chapter included varying degrees of sustainable design elements in their design and building projects. Despite the variation however, the coordinators for all the projects each worked from similar philosophical foundations in their application of sustainable principles to design and project management. It is critical to embrace those principles to realize the benefits that result from a successful application of sustainable design features.

The three cases present examples of how differences in support from decision-making levels of leadership can affect the outcome of a project. Each project clearly shows that leadership at the top is critical if a school is to be designed to minimize its impact on the earth, to be a healthy and enjoyable environment for occupants and to be a cost-effective building to operate. In the Sakai and Roy Lee Walker projects, the school boards were behind the decisions to use sustainable design. Coordinators who understood and supported those goals were assigned to manage the projects. The Newport Coast project also had champions to follow through on goals for sustainability. However, because of client concerns, the scope of those goals were narrowed to specifically address energy-efficiency.

While both the Sakai and Roy Lee Walker projects were comprehensive in their embrace of sustainable design applications, the Roy Lee Walker project led to a more comprehensive application of certain features simply because of the direction set from the beginning of the project. Leadership at Sakai clearly stated three environmental goals that were to be met by design decisions. Those goals were pursued comprehensively and with sensitivity. In contrast, in Texas, the goal was set to build a "sustainable elementary school." That decision resulted in a planning process that questioned every conventional design application from energy use to landscape design. The architect was brought into the process with the understanding that the total design should be based on sustainable principles. The Roy Lee Walker project, of the three, perhaps represents the one where the intent to totally embrace principles of sustainable design is best represented.

It is important to note that in all three projects experts in the field of sustainable design and in the use of sustainable materials were brought in as consultants, or in the case of Newport Coast, as project coordinators. Understanding of applications of sustainability is an evolutionary process. Participants in the process will learn from both from their own and others applications. It can be useful, and also very effective, to use experts in the field to help with the education and guidance that leads others to understand that the application of sustainable principles can result in both successful and cost-effective design.

Collaboration across teams of project participants, including community participation, was also clearly an important component of all three projects. Commentary and analysis by the community led to more open discussions of the plans and, in some cases, extensions in the time it took for plan review and approval. All the project participants interviewed for this paper were supportive of the public process while also acknowledging the reality of the frustrations that may accompany it. The use of the building as a teaching tool for students to learn about environmental stewardship was also an important element of each project and it represents another means of realizing community involvement.

As with any project of the scale these represent, realities of budget constraints arose in all three cases. The project coordinators were faced with making compromises while still working to keep intact the goals for sustainable design. Decisions were made based on least-impact to sustainable principles while also considering the reality of the particular dynamics at play for each of the school districts.

Finally, each school design represents its own unique design that is appropriate to the site. While that may seem like an obvious point it is an important one to realize in that it points out that sustainable design is not a particular design style. It represents, instead, a philosophical approach to building that is sensitive to the needs of the site and of the client. The architect and project participants may be creative in any number of ways to create a design that meets the requirements of the principles of sustainable design.

CLOSING COMMENTS

Application of sustainable design to the design of schools presents the opportunity to merge principles of learning with a physical environment that is built to support those principles. Sustainable design can lead to the creation of learning centers that offer students, and the adults who work with them, an environment that supports and enhances the learning and teaching experience. Concurrently it can also result in the construction of a learning center, a school, that represents an environmentally responsible design founded on a respect for the natural systems and communities that are impacted by the design.

Our efforts to dramatically improve the effectiveness of education delivery in the Twenty-first Century would be positively impacted by application of sustainable design principles to school building. School communities that are proactive in their embrace of the principles of sustainable design will realize the greatest returns. Sustainably designed centers of learning can stand as symbols of support for a healthy community by being

> ... wonderful building(s) – ... building(s) that (are) bright and well-lit, that (are) warm in winter and cool in summer, that (are) as comfortable as (they are) healthy, that (are) energy- and resource- efficient, that (are) functional and long-lived, and that promote the well-being of (their) occupants and the earth (Rocky Mountain Institute, 1998, p.13).

The challenge is ours to embrace.

APPENDIX A

IMPACT OF INADEQUATE SCHOOL FACILITIES ON STUDENT LEARNING

Impact of Inadequate School Facilities on Student Learning

U.S. Dept. of Education: http://www.ed.gov/inits/construction/impact2.html

A number of studies have shown that many school systems, particularly those in urban and high-poverty areas, are plagued by decaying buildings that threaten the health, safety, and learning opportunities of students. Good facilities appear to be an important precondition for student learning, provided that other conditions are present that support a strong academic program in the school. A growing body of research has linked student achievement and behavior to the physical building conditions and overcrowding.

Physical Building Conditions

Decaying environmental conditions such as peeling paint, crumbling plaster, nonfunctioning toilets, poor lighting, inadequate ventilation, and inoperative heating and cooling systems can affect the learning as well as the health and the morale of staff and students.

Impact on student achievement

- A study of the District of Columbia school system found, after controlling for other variables such as a student's socioeconomic status, that students' standardized achievement scores were lower in schools with poor building conditions. Students in school buildings in poor condition had achievement that was 6% below schools in fair condition and 11% below schools in excellent condition. (Edwards, 1991)
- Cash (1993) examined the relationship between building condition and student achievement in small, rural Virginia high schools. Student scores on achievement tests, adjusted for socioeconomic status, was found to be up to 5 percentile points lower in buildings with lower quality ratings. Achievement also appeared to be more directly related to cosmetic factors than to structural ones. Poorer achievement was associated with specific building condition factors such as substandard science facilities, air conditioning, locker conditions, classroom furniture, more graffiti, and noisy external environments.
- Similarly, Hines' (1996) study of large, urban high schools in Virginia also found a relationship between building condition and student achievement. Indeed, Hines found that student achievement was as much as 11 percentile points lower in substandard buildings as compared to above-standard buildings.
- A study of North Dakota high schools, a state selected in part because of its relatively homogeneous, rural population, also found a positive relationship between school condition (as measured by principals' survey responses) and

both student achievement and student behavior. (Earthman, 1995)

- McGuffey (1982) concluded that heating and air conditioning systems appeared to be very important, along with special instructional facilities (i.e., science laboratories or equipment) and color and interior painting, in contributing to student achievement. Proper building maintenance was also found to be related to better attitudes and fewer disciplinary problems in one cited study.
- Research indicates that the quality of air inside public school facilities may significantly affect students' ability to concentrate. The evidence suggests that youth, especially those under ten years of age, are more vulnerable than adults to the types of contaminants (asbestos, radon, and formaldehyde) found in some school facilities (Andrews and Neuroth, 1988).

Impact on teaching

- Lowe (1988) interviewed State Teachers of the Year to determine which aspects of the physical environment affected their teaching the most, and these teachers pointed to the availability and quality of classroom equipment and furnishings, as well as ambient features such as climate control and acoustics as the most important environmental factors. In particular, the teachers emphasized that the ability to control classroom temperature is crucial to the effective performance of both students and teachers.
- A study of working conditions in urban schools concluded that "physical conditions have direct positive and negative effects on teacher morale, sense of personal safety, feelings of effectiveness in the classroom, and on the general learning environment." Building renovations in one district led teachers to feel "a renewed sense of hope, of commitment, a belief that the district cared about what went on that building." In dilapidated buildings in another district, the atmosphere was punctuated more by despair and frustration, with teachers reporting that leaking roofs, burned out lights, and broken toilets were the typical backdrop for teaching and learning." (Corcoran et al., 1988)
- Corcoran et al. (1988) also found that "where the problems with working conditions are serious enough to impinge on the work of teachers, they result in higher absenteeism, reduced levels of effort, lower effectiveness in the classroom, low morale, and reduced job satisfaction. Where working conditions are good, they result in enthusiasm, high morale, cooperation, and acceptance of responsibility."

A Carnegie Foundation (1988) report on urban schools concluded that "the tacit message of the physical indignities in many urban schools is not lost on students. It bespeaks neglect, and students' conduct seems simply an extension of the physical environment that surrounds them." Similarly, Poplin and Weeres (1992) reported that, based on an intensive study of teachers, administrators, and students in four schools, "the depressed physical environment of many schools... is believed to reflect society's lack of priority for these children and their education."

Overcrowding

Overcrowded schools are a serious problem in many school systems, particularly in the inner cities, where space for new construction is at a premium and funding for such construction is limited. As a result, students find themselves trying to learn while jammed into spaces never intended as classrooms, such as libraries, gymnasiums, laboratories, lunchrooms, and even closets. Although research on the relationship between overcrowding and student learning has been limited, there is some evidence, particularly in high-poverty schools, that overcrowding can have an adverse impact on learning.

- A study of overcrowded schools in New York City found that students in such schools scored significantly lower on both mathematics and reading exams than did similar students in underutilized schools. In addition, when asked, students and teachers in overcrowded schools agreed that overcrowding negatively affected both classroom activities and instructional techniques. (Rivera-Batiz and Marti, 1995)
- Corcoran et al. (1988) found that overcrowding and heavy teacher workloads created stressful working conditions for teachers and led to higher teacher absenteeism.

Crowded classroom conditions not only make it difficult for students to concentrate on their lessons, but inevitably limit the amount of time teachers can spend on innovative teaching methods such as cooperative learning and group work or, indeed on teaching anything beyond the barest minimum of required material. In addition, because teachers must constantly struggle simply to maintain order in an overcrowded classroom, the likelihood increases that they will suffer from burnout earlier than might otherwise be the case.

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APPENDIX B

INTERVIEW QUESTIONS

Interview Questions Submitted by Anne W. Fox

Schools: Design for Sustainability

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1. How was project initiated? What is (was) your involvement with the project?

2. What was identified as a problem with the existing school facility? What is the basis in history for cause of the problems? Is it a new school (rather than a renovation or replacement)? If so, is the district in need of a number of new schools?

3. What is (was) scope/goal of the project?

4. What was community involvement? How? Who? Length of time?

5. What was reaction of various stakeholder groups to the proposal? Did reaction vary according to time of presentation in relation to planning and development of project?

6. How much time went into working with the community?

7. Do you have thoughts about how you might change (or not) your approach to community participation?

8. What management structure was used to facilitate planning/designing/building the project? What is construction management versus design/bid/build process? Pro/Con for both? How is this process different from conventional management of projects?

9. What does sustainable design mean in the case of your project?

10. What specific design elements related to sustainable practices are incorporated into the project?

11. During construction were any specific features intended to create SD compromised?

12. Does design incorporate intentional strategies for physical as well as emotional wellbeing?

13. Do you have or have you seen WSD schematics that depict how a buildings components are interdependent and linked?

Interview Questions (continued)

14. Was a cost analysis done? Cost/sq.ft. v. other traditional measures? Were any savings calculated based on future operations and maintenance cost projections?

15. Will a follow-up analysis be done? If so what targeted areas?

16. How do requirements for floating bond issues years before building affect the design process? Are districts using any new approaches to funding to look ahead to alleviate some of today's problems?

17. What is your view of the state of sustainable design for schools? Do you collaborate with other school districts or with the municipality/county that houses your district? Do the schools within your district share information about sustainability issues?

18. What issues/concerns/key points/conceptual thoughts do you think should be communicated in a paper about sustainable school design?

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